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LIGHT FROM THE LABORATORY AND THE CLINIC ON

THE CAUSES OF PEPTIC ULCER*

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FOR more than fifty years able men have been struggling with the problem of peptic ulcer, trying to find out why the stomach does not ordinarily digest itself, why acute ulcers heal, and why chronic ones either fail to heal or else, when they do heal, tend to become active again.

ACUTE EXPERIMENTAL ULCERS

I shall not attempt to review here the enormous literature that has grown up about the subject of ulcer causation; von Redwitz and Fuss did not waste any words and yet their splendid analysis of the subject covers 387 pages. Hauser's great monograph, which represents notes collected during the course of a long life, is even more extensive. All I can hope to do here is to comment on a few of the discoveries that seem to me to throw light on the problem of chronic peptic ulcer as it appears to the clinician, the surgeon and the physiologist.

As Cohnheim saw so clearly in 1880, the difficulty facing the experimenter has not been to produce ulcers; his trouble has been to make chronic ones that will not promptly heal. Many laboratory workers in the last fifty years have snipped out bits of mucosa from the stomachs of animals; they have injected caustics and toxins and bacteria and have produced necrotic areas or hemorrhagic patches, but except in rabbits (Ferguson, Fauley and Ivy), these defects have always healed over promptly just as do the wounds made by surgeons in the stomach and duodenum of man.

THEORIES OF ULCER CAUSATION INADEQUATE

There are a number of theories of ulcer causation, some helpful but none entirely satisfactory to the clinician because they do not explain the peculiarities of the disease as it occurs in man. Thus they do not tell us why in this country men are more subject to the disease than women, and why in some other parts of the world men and women are equally affected. They do not explain why jejunal ulcer is seen ten times as often in men as in women, and they do not help us to understand why today, in America, duodenal ulcer is so much more common than gastric ulcer when in some parts of Europe the reverse appears to be true now or to have been true in the past. They do not explain why duodenal ulcer tends to come in the twenties and thirties and why gastric ulcer tends to come in the thirties and forties. They do not explain why gastric ulcers usually cease growing when they are 2.5 cm. in diameter and why duodenal ulcers are only half as large. One wonders why

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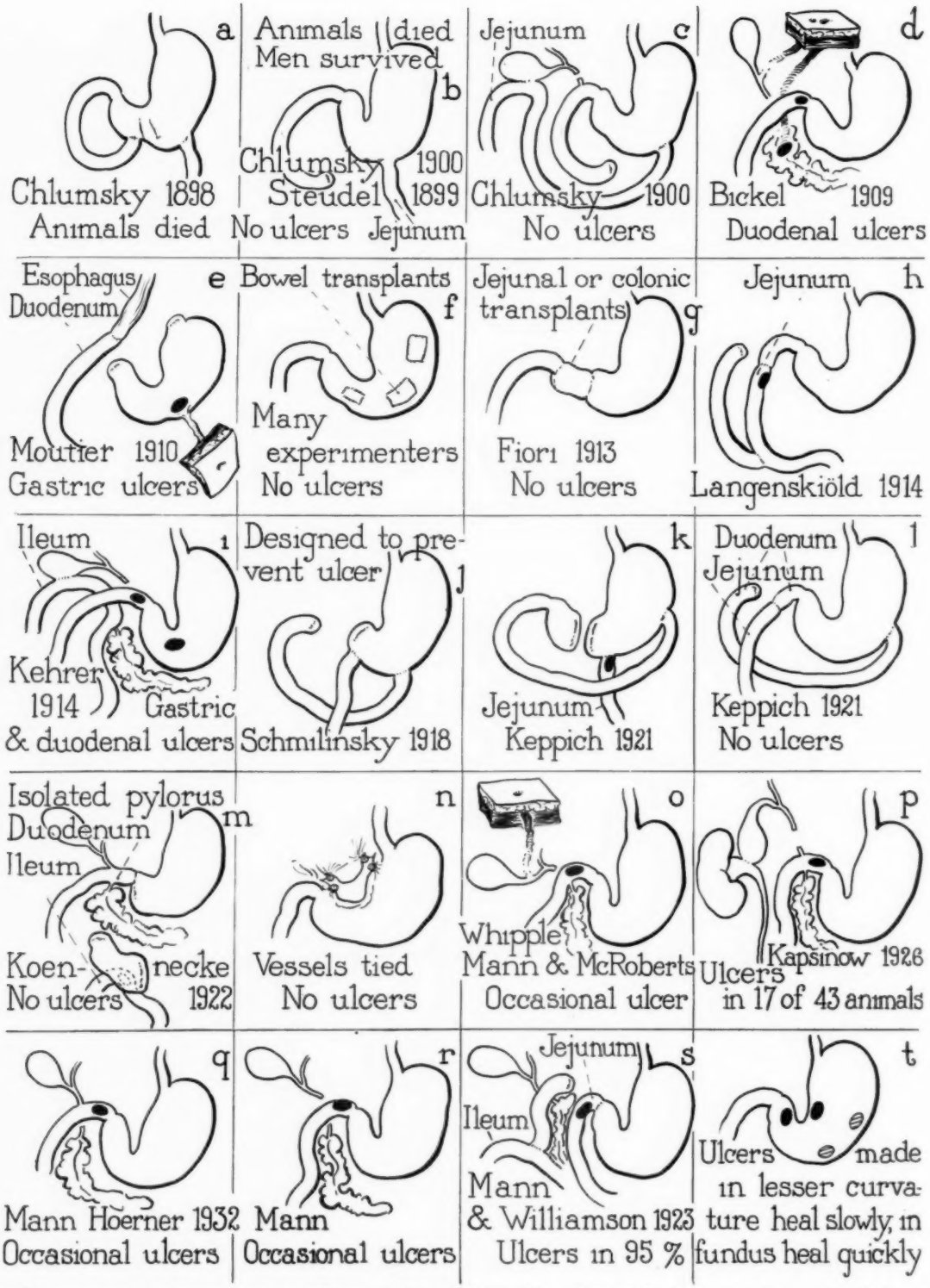

FIG. 1. Diagrammatic representations of operations performed on dogs with the hope of throwing light on the causes of peptic ulcer.

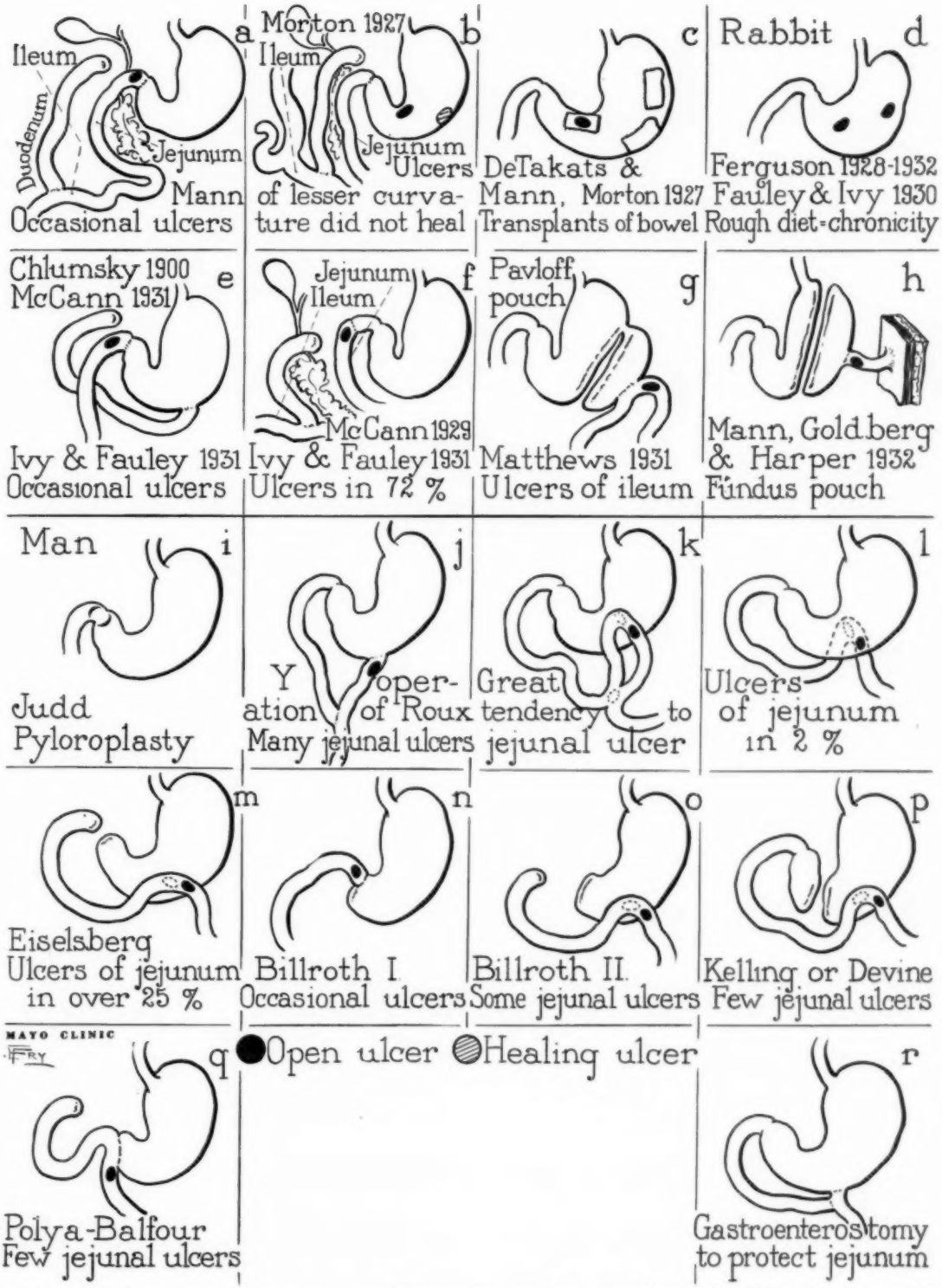

FIG. 2. (*a* to *b*) Diagrammatic representations of operations performed on dogs and rabbits with hope of throwing light on causes of peptic ulcer. (*i* to *q*) Diagrammatic representations of operations performed on man with the hope of curing ulcer. (*r*) A suggested operation to cure ulcer.

there should be any limit to the destructive process once it is started. Why also are ulcers so often single? It would seem as if the causes that produce one might just as well produce another. Furthermore there is no entirely satisfying explanation of the fact that perhaps nineteen out of twenty ulcers are to be found in either one of two small areas in stomach and bowel. Every so often a writer thinks he has answered some of the questions about ulcer only to realize later that while his explanation may be applicable to lesions in the duodenum it is useless when it comes to explaining those in stomach and jejunum.

ARTERIAL CHANGES

A number of investigators have shown that ulcers can form in the stomach of man when one of the gastric blood vessels is narrowed or plugged, and some have suggested that the disease is commonly due to arteriosclerosis or embolism. Endarteritis can doubtless be demonstrated in the neighborhood of some ulcers, and, when present, it should have a restraining influence on healing. In many cases of ulcer, however, it has been impossible to show much if anything wrong with the vessels, either in stomach or duodenum. In other cases the arterial changes have been found only in or around the floor of the ulcer, in which case the natural supposition is that they are secondary to inflammation, and that they serve a useful purpose in protecting the patient from hemorrhage.

If arterial degeneration were a common cause of ulcer, one would expect to find the disease beginning commonly in elderly people and not, as is the case, in youths and young adults. It may well be, however, that arteriosclerosis is the cause of some ulcers, and particularly of those which form late in life.

Although actual arterial *disease* does not appear to be a common cause of ulcer, especially in young people, the possibility remains that arterial *spasm* is one of the links between the emotions and ulcer. An argument against these theories is to be found in the fact that a number of investigators have been able to tie off from one-third to four-fifths of the gastric blood supply in animals without producing necrosis (Fig. 1*n*). In some cases they could show, with the help of vital stains, that an injury had been wrought to the cells in the affected area of mucous membrane, and in a few instances acute ulcers were produced. It seems to me probable that when certain vessels are tied, blood continues to reach the mucous membrane by way of connecting branches, and injury does not result, but if a vessel is closed throughout its length by spasm or disease the cells dependent on it for blood must die. Thus, when Payr tied off large vessels to the stomach he occasionally produced an acute ulcer but when he injected into a small gastric artery a few drops of a dilute solution of formol he obtained, in a number of the animals, chronic and even perforating ulcers. Subsequent examination showed that the lumen of the injected vessels had been much narrowed.

Many experimenters reported also that they could produce superficial ulcers by poisoning animals with sublethal injections of pilocarpin and physotigmin. The drug produced so much spasm of some of the gastric vessels that small round areas of anemic or cyanotic muscle and mucosa could be seen to form. According to Gallagher acute ulcers formed in the duodenum whenever he clamped the mucous membrane and made it anemic for more than thirty minutes. We have here, then, a possible explanation for the small size of most ulcers: that is, their area corresponds perhaps to that supplied by a small artery.

The question next arises: But why doesn't an erosion made in this way heal as soon as the spasm relaxes? Certain experimental work suggests that the presence of a defect in the mucosa tends to draw to it or concentrate about it all the tendency to muscular spasm that is engendered in stomach and duodenum by

an overly irritable vagus nerve, and it may be that in this way a vicious circle is set up. There is some experimental evidence to show also that harmful substances can pass through the ulcer and into the sheath of the vagus nerve to cause even more irritability.

Against the theory of ulcer causation through arteriolar spasm is the observation of Stahnke that long-continued electrical stimulation of the vagus nerves caused relaxation of the gastric vessels at the same time that it produced hyperperistalsis and powerful contraction of the muscle. Stahnke doubted if Nature would have made a nervous mechanism that would increase muscular and secretory activity and at the same time shut off the supply of much needed blood.

Reeves, Disse, Jatrou, Hoffman and Nather, Berlet, and others have shown that the small blood vessels supplying the mucous membrane in the ulcer-bearing zone along the lesser curvature of the stomach and in the duodenal cap are peculiar and perhaps more like endarteries than are the vessels elsewhere in the digestive tract. Working independently, they all came to the same conclusion: that the duodenal cap is poorly supplied with blood and therefore markedly predisposed to injury and to poor healing afterward.

Histologists have pointed out also that the mucous membrane along the *Magenstrasse* is much like that in the intestine. Besides, it is so firmly attached to the muscle that it cannot slip away from foreign bodies that may impinge upon it. It may be significant that the mucous membrane in the duodenal cap is also firmly attached to the muscle. Bauer has emphasized the point that the lesser curvature of the human stomach is, in a way, a vestigial organ in that it represents what is left of the furrow which in some of the lower animals carries liquids into the pyloric stomach. Like some other vestigial structures it may be particularly subject to disease. Against this idea is the probability that man comes of a stock that never possessed a complicated stomach of the ruminant type.

One is tempted then, to look to definite histologic peculiarities for an explanation of the fact that in man the region in the stomach near the incisura is so highly susceptible to ulcer until one learns of the work of de Takats and Mann, Morton and others who showed that segments of intestinal mucosa transplanted into the wall of the stomach seldom become ulcerated except when they are placed along the lesser curvature (Fig. 2 *c*.). These experiments show that the susceptibility of this region cannot be ascribed wholly to anatomic peculiarities but must be due at least partly to its exposure to some extra strain or mechanical or chemical injury. In conformity with this view is the fact established by many investigators, that acute ulcers heal faster when they are made in the fundus of the stomach and along the greater curvature than when they are made in the *Magenstrasse* (Clairmont, Morton, and others).

As is well known, there is almost no peristalsis in the fundus and little chance for mechanical injury to the mucosa. Against this theory of mechanical stress however is the fact that if friction were the most important factor in determining the location of ulcers in the stomach, then they should be found commonly in all parts of the pars pylorica and particularly in the pyloric ring. Actually they seldom occur there. One explanation offered is that the attachment of the mucous membrane to the muscle in the pyloric region is so loose that the mucous membrane can slip away from an impinging body such as a piece of bone.

Many physicians have assumed that in man the *Magenstrasse* or gastric furrow carries fluids from cardia to pylorus much as it does in some of the lower animals. My own observations, together with those of several roentgenologists, make me doubt if this is true. When, on a few occasions, I gave barium and water to a person who had just dined, the fluid seemed to run

over the mass of food in the stomach on all sides much as frosting would run over a cake, and I could not see that any large amount followed the lesser curvature. (For the literature see Hauser, p. 698.)

INFECTIOUS THEORY

Since the work of Böttcher in 1874, the literature has been full of reports of cases that show that at times infection can give rise to acute ulcers or, more often, to transient hemorrhagic erosions. The infectious theory of ulcer causation leaves much to be desired, however, because it does not throw light on any of the peculiarities of the incidence of the disease. Thus, it does not seem likely that focal infection is three times as common in men as in women, and I doubt if it is much more common at the age of twenty-five than it is at forty-five years. Besides, time and again I have seen ulcer symptoms return to disable a patient whose discoverable focal infections had all been removed, and just as frequently I have seen an ulcer heal spontaneously and stay healed for a long time in a patient whose mouth was full of devitalized teeth and carious snags.

The work of Rosenow, Haden and Bohan, Nickel and Hufford, and others is suggestive but as yet it is hard to say what relation the hemorrhagic patches and acute ulcers produced by them in rabbits have to the chronic ulcers of man. Incidentally, Ivy has produced hemorrhagic patches by injecting sterile broth cultures containing lampblack which makes one wonder if the bacteria do not at times serve as simple emboli in the small gastric and duodenal vessels. On the other hand several experimenters have obtained the same type of lesion by injecting bacterial toxins alone. According to Emery and Monroe foci of infection are no more common in patients with ulcer than in those without it. Unfortunately the difficulties to be overcome in gathering sufficient data to prove or disprove the value of removing focal infections in cases of chronic ulcer are so great that I doubt if the task can ever be accomplished to the satisfaction of everyone. In the meantime the physician may remove focal infections on general principles or because he has faith that such work will cure ulcer, but I do not see how he can promise the individual patient anything.

I like to clean up those lesions in mouth and nose which can produce a steady stream of pus down the esophagus. I have no statistical proof with which to back up my belief but it seems to me logical to assume that an ulcer should heal better when not bathed day and night in infectious material. Against this idea is the fact that ulcers are seen most commonly in the men and women who have the most bactericidal gastric juice.

One of the difficulties in analyzing the influence of infection on ulcer arises in the fact that in so many cases foci immensely larger and more important than those in teeth, tonsils, or prostate gland are present and unrecognized in appendix, gallbladder, liver, mesenteric lymph nodes, and, in the case of perforated ulcers, in the mass of inflammatory tissue surrounding the lesion.

The most fertile source of infection producing flare-ups of ulcer symptoms seems to be the common cold. As Eusterman has pointed out, gastric hemorrhages often follow an attack of influenza or sinusitis. Occasionally the infection appears to enter through the skin; thus, I know of two physicians who suddenly found themselves with acute and very painful duodenal ulcers, demonstrable with the roentgen ray. One had a felon on the finger and the other an infected wound. These ulcers healed symptomatically and the crater disappeared a few days after the source of infection was removed. Most of us probably suffer from time to time with acute ulcers of infectious or nervous origin just as we suffer with canker sores or herpes labialis. The fortunate thing is that in those of us who are perhaps free from a "spasmophilic tendency" or an "ulcer diathesis," these lesions promptly heal.

TYPE OF PATIENT WHO GETS ULCER

Before launching into a study of the methods used for the production of experimental ulcer it might be well to review briefly a few of the clinical peculiarities of the disease. There is no question that it tends to run in families, and that the hereditary factor is at times important. What we all need to know now is the nature of the inherited defect or deficiency. Much evidence is accumulating to show that in many cases the tendency to the formation of ulcers is based on the abnormally high reactivity of the individual. He is often a keen, wide-awake, sensitive type of man who drives himself all day and part of the night, who responds too much to things that break into his routine, and who does not know how to relax.

Anyone with large clinical experience will doubtless feel inclined to remind me that many patients with ulcer do not conform to this type, and that many persons of this type never suffer with ulcer. While admitting this, I must point out that many persons who are outwardly calm are inwardly tense, anxious, fearful, or actually seething. To me it is a curious fact that in many persons tenseness and nervousness do not seem to give rise to any disease while in others they tend to produce perhaps a nervous breakdown, attacks of migrain or mucous colitis, or a steadily mounting blood pressure. Other nervous persons suffer for years with an ulcer-like syndrome, the mechanism of which is not yet known.

PSEUDO-ULCER

A few of the patients with pseudo-ulcer eventually are found to have one or more ulcers, but most of them live on for years without the development of a definite lesion. Often the symptoms are so striking that the clinician must wonder if the negative report from the roentgenologist is correct, but we at The Mayo Clinic have found from long experience that especially when the history is somewhat atypical, when there is distress before breakfast and none at night, and when the symptoms have been practically constant for years without the customary remissions, and without the appearance of signs of obstruction or perforation or hemorrhage, it seldom pays to disregard the evidence obtained in the dark room. Too often at operation on such patients the most careful search will fail to reveal an ulcer.

Some of the patients with pseudo-ulcer or with ulcers that tend to recur and become disabling in spite of every form of medical and surgical treatment have at all times a marked and uncontrollable hyperacidity, but others do not, and not infrequently one sees a person whose ulcer refuses to heal in spite of the fact that the acidity is so low that there cannot be much peptic activity in the stomach. Furthermore there are persons who live out their lives with a gastric acidity far above normal and yet never show symptoms or signs of ulcer.

HYPERACIDITY IS NOT THE ONLY CAUSE OF ULCER

In mentioning the presence of low acids in some cases I do not wish to obscure the fact that a persistently high acidity is often a prominent characteristic in cases of severe and intractable ulcer; I only wish to warn the reader against a too ready acceptance of the popular view that hyperacidity is the sole factor in the production of the disease. Recent studies (Vanzant et al.) show that gastric ulcers are associated, on the average, with acidity slightly lower than normal, and one has only to see one of the rare cases of chronic ulcer and no free gastric acidity (by ordinary tests) or a few cases of elderly men with a free acidity around 80 units and no sign of ulcer, to realize that other factors besides acidity must often enter in before an ulcer can be formed or maintained in a chronic state.

Mann and Bollman have had every reason to be impressed by the importance of acidity in the production of experimental

ulcers, and they and their students have shown clearly enough that the duodenum or jejunum that succumbs to ulceration probably does so because it is exposed too long to concentrations of acid which are higher than normal for the particular region involved. This factor of unusual or prolonged exposure impresses me more than the one of simple gastric hyperacidity. When I remember how large the factors of safety are in most of the functions of the body it is hard for me to believe that an increase in gastric acidity to only one and a half or at most to twice normal could, alone, be responsible for the formation of ulcer. I know it is possible but I have reasons for suspecting that future research on patients with ulcer will show an absence from the gastric juice of some substance which normally tends to protect the mucous membrane from injury by hydrochloric acid. (See Matthes, Ivy and Fauley, Mann and Bollman.)

Curiously, Dragstedt found years ago that acute ulcers produced in a gastric pouch made so as to retain its secretion, healed as quickly as did ulcers in a pouch in which the juice was not retained. Somewhat against this observation is that of Hughson, Bolton, Friedman and Hamburger, Ivy and Fauley and others, who found that the production of some degree of obstruction at the pylorus, which usually increases the acidity, delayed the healing of experimentally produced gastric ulcers. By itself, experimentally produced pyloric stenosis rarely seems to lead to the production of ulcers. Slocumb is the only one whom I have found reporting much success with this technique.

DIFFERENT TYPES OF ULCER IN MAN

An important point to be kept in mind is that there are doubtless *several causes for ulcer* and several types of the disease in different parts of the world. This was brought home forcibly to us at The Mayo Clinic by Walters and Snell who recently went to Germany to see why the gastroenterologists in that country are always talking about a gastritis that precedes or is associated with ulcer. We were puzzled about it because we so rarely see it in Rochester. Actually Walters and Snell found that in some parts of Germany duodenal ulcer is usually associated with a diffuse inflammation and ulceration of the mucous membrane of the distal end of the stomach, and they could easily understand why, under the circumstances, European surgeons like to resect widely. Later, Dr. Sebening of Frankfurt spent some time with us at the Clinic and was equally impressed by the fact that the pathology of ulcer is different in the United States and in Germany. Recently Aschner showed that many of the bits of stomach resected in New York contain multiple lesions resembling those seen in Germany. The next question is: Why are these differences so marked?

Perhaps as time goes on, much can be learned about the causes of ulcer by studying its incidence in different countries and among peoples who have different dietary customs. I need but mention the reported high incidence of ulcer in Abyssinia where the people take their food covered with pepper (Bergsma), or the peculiar distribution of ulcer cases in Southern India where a diet of tapioca is supposed to be responsible for the disease (Sommervell, McCarrison). It appears to be unusually common also in Denmark and among soldiers stationed in Hawaii.

It has interested me much to find in Minnesota a marked tendency of ulcer symptoms to flare up in the spring and in the fall. I do not remember having seen this in California where the seasons are not so marked, and Larsen of Honolulu writes me that it is not seen in that winterless climate.

WHY DOESN'T THE STOMACH DIGEST ITSELF?

The earliest workers on the problem of ulcer were naturally concerned with the question: why doesn't the stomach digest

itself? At first its immunity was thought to be due to the alkalinity of the circulating blood and later to a postulated antipepsin. When an antipepsin could not be demonstrated to the satisfaction of everyone, most experimenters fell back on the statement that there is something about the *living* cell that protects it. They transplanted the spleen and kidney and bits of bowel into the wall of the stomach, and so long as the circulation of the graft was unimpaired there rarely was any sign of digestion in it (Fig. 1 *f*). (Hotz, Exalto, de Takats and Mann, Morton, Dogliotti and Riccio, and Dragstedt and Vaughn.)

Necheles, Ling and Fernando found that healthy living tissues implanted into the duodenum or upper jejunum were not digested. When, however, they injured the pancreas by injecting sterile olive oil into the main duct, digestion of the implants took place and the mucous membrane of the whole stomach and small intestine showed signs of hemorrhagic inflammation.

According to Michaelis the living cell is immune to peptic activity probably because its limiting membrane contains lipoids which cannot be attacked by a protein-splitting ferment. This theory sounds plausible until one gets to wondering why activated pancreatic lipase does not initiate destruction of the duodenal mucosa and why cells are not digested by their own proteinases.

Actually, in many instances, the first and all-essential injury to the limiting membranes of the gastric or duodenal cells is probably wrought by strong concentrations of hydrochloric acid or by gastric juice which is not modified in some way by duodenal secretions. The work of Matthes, reported in 1893, shows that the mucous membrane of the living bowel is promptly injured by hydrochloric acid of from 0.2 to 0.5 per cent concentration. He used dogs with Thiry fistulas. Strange to say, natural gastric juice from a pig was much less irritating than artificial juice made by adding pepsin to dilute hydrochloric acid. He tried adding mucin to the artificial juice to see if he could temper its action in this way but without result.

Langenskiöld repeated Matthes' work, using large amounts of pure gastric juice from dogs. This juice was run into the stomach through a catheter and out through another catheter placed in the duodenum. The animals were then killed and the mucous membrane studied. Especially when the juice had been in contact with the mucous membrane for as long as three hours excoriations were found and sometimes ulcerations which extended down to the muscularis mucosae.

Most interesting was one experiment in which after four hours of bathing the mucous membrane with pure gastric juice Langenskiöld was puzzled at finding little sign of irritation. Investigation soon showed that in this case the animal had eaten a little meat an hour before the experiment was started. Acting on the hint derived from this accidental discovery, Langenskiöld performed another series of experiments in which he bathed the gastric and intestinal mucous membrane first with 500 c.c. of a saturated solution of Witte's peptone and then with the acid. As he had expected, he found that the presence of peptone in the tissues protected them from digestion. Similar observations have recently been made by Mann and Bollman who took dogs with a gastric fistula and injected 0.4 per cent hydrochloric acid, drop by drop for eight hours a day. After two weeks the resistance of the mucosa to this insult seemed to fail, and the animals rapidly lost weight. In another two weeks a chronic ulcer could usually be found near the lesser curvature. The presence of this lesion made the mucous membrane even less resistant to injury by acid than it was before, and the stomach and duodenum were made highly sensitive as shown by the tendency of the animal to vomit as soon as the experiment was started.

Most interesting is the fact that if the dog was given a little food before the daily experiment started, and even if the remnants from this food were later washed out,

the gastric mucosa was resistant to the harmful action of the acid, and what is more, it rapidly neutralized the acid. These experiments are of tremendous importance because they show the physician that when he gives food at frequent intervals to a patient with ulcer, this food serves not only to sop up the gastric acid but it does something to the mucous membrane which serves to protect it from injury. What we physicians have learned to do empirically is now shown experimentally to be based on a firm foundation.

As is well known, inactivated pancreatic juice is inert, and according to Matthes and others, the active form of trypsin does not ordinarily attack living cells. I have not yet been able to find much evidence to indicate that the pancreatic juice causes ulcers.

There is ample evidence to show that the shutting off of the circulation to cells promptly produces changes in them which make them subject to digestion by ferments. Ivy was particularly impressed in his experimental work with the fact that inanition or cachexia in an animal predisposes some of its cells to digestion and leads at times to the formation of ulcers. Other experimenters and some clinicians have commented on the deleterious effects of anemia in the healing of ulcers. Somewhat against this view is the fact that Ewald tried in vain to produce ulcers by feeding hydrochloric acid to anemic dogs.

It may be of interest to note that not infrequently the drinking of much cold water by an overheated mountaineer will give rise to painful symptoms which suggest the presence of an acute ulcer. It is possible that the cooling of the cells in the mucosa injures them to such an extent that later they succumb to the digestive action of the gastric juice.

FIRST CHRONIC ULCERS DISCOVERED IN ANIMALS

As was pointed out early in this article, almost all of the ulcers produced by the first experimenters were shallow lesions or hemorrhagic patches which soon healed. In a few cases typical, chronic, punched-out, bleeding, or perforating and death-dealing ulcers were discovered, usually after operations designed to divert the bile or the pancreatic juice from the duodenum (Whipple, Ivy and Fauley, Jona, Kapsinow, Gallagher, Elman and others) (Fig. 1 *o*, *p*, *q*, *r*). Bollman and Mann discovered chronic duodenal ulcers in many dogs with a true Eck fistula, and particularly in those which were given a coarse diet.

In 1903 Watts, while studying gastroenterostomy in dogs, lost one of his animals with a perforated jejunal ulcer, and since then a number of experimenters have had a similar experience. Dott and Lim, Montgomery and others found them occasionally after gastroenterostomy with exclusion of the pylorus, and surgeons soon learned that this type of operation (v. Eiselsberg's) must not be done on account of the high percentage of jejunal ulcers which appear later. (Fig. 2 *m*.)

In 1908 Borszeky produced a perforating jejunal ulcer in a dog operated on with a Y type of gastroenterostomy and given hydrochloric acid, and in 1911 Exalto had similar success with five of seven dogs operated on with the Y operation (Fig. 2 *j*). Exalto realized that this type of gastroenterostomy is dangerous because the jejunum at the anastomosis with the stomach is not bathed in the neutralizing secretions which normally come down from the duodenum.

Later Exalto, von Roojen and others gathered statistics to show that in man the number of jejunal ulcers seen after the Y operation is so great that it should seldom be used. A number of surgeons then became afraid of anterior gastroenterostomy with enteroanastomosis because with this operation the duodenal juices do not have to go past the orifice in the stomach (Levai). One would think that the question of safety or danger in this operation could be settled quickly by an appeal to statistics, but as Balfour has pointed out, surgeons today perform an-

terior gastroenterostomy only when adverse conditions make it impossible for them to do anything else, and naturally the results ought to be worse than those secured with a posterior anastomosis and a short loop. (Fig. 2 *k*.)

To avoid this objection one has to go back to old statistics gathered in the days when anterior gastroenterostomy was the only operation used. Rather impressive in this regard is the paper of Schwarz in 1914 who recorded that before 1908, with a comparatively small series of cases in which anterior gastroenterostomy and enteroanastomosis had been performed, nine jejunal ulcers occurred. He then changed to the modern type of posterior gastroenterostomy and in his next 167 cases had only one jejunal ulcer.

A number of other surgeons have claimed that the percentage of jejunal ulcers obtained with anterior gastroenterostomy is high (Wright) but others say this is not proved, and von Redwitz and Fuss, who searched the literature on this point decided that the operation has given results comparable with those obtained with posterior gastroenterostomy. Montgomery, in a number of dogs, made an anastomosis between the afferent and efferent loops and obtained only one jejunal ulcer. So far as his experience with animals went, he was not impressed with the danger of doing this operation.

A number of early investigators tried to produce ulcers in dogs by giving hydrochloric acid daily but they did not have much success. As Mann and Bollman have now shown, the acid must trickle through the stomach for hours and days until the resistance of the mucosa is exhausted. Matthes found that giving acid would delay the healing of an ulcer produced by injury to the mucosa. As will be seen later, striking results were obtained when a strong gastric juice was produced through daily stimulation of the vagus (Stahnke).

Most interesting of the earlier chance observations on ulcer is that of Bickel who in 1909 operated on two dogs (Fig. 1, *d*). Wishing to remove the duodenum, he closed the pylorus, performed gastroenterostomy, and then brought the biliary and pancreatic ducts out to the skin. A month later one of the animals died from peritonitis due to perforation of one of several ulcers which had formed in the upper part of the jejunum. Bickel promptly recognized the fact that the presence of bile and pancreatic juice in the upper part of the duodenum might be one of the most important factors in preventing the formation of jejunal ulcers after gastroenterostomy.

Realizing the value of this work, Langenskiöld, in 1914, severed the duodenum a short distance from the stomach and closed the distal end (Fig. 1, *b*). He then cut the jejunum across several centimeters below the duodenum and joined the aboral end to the stump of the duodenum. The oral end of the jejunum was anastomosed with a loop of jejunum farther caudad, thus shunting the pancreatic and biliary secretions into the middle of the small intestine. A month later, as the animal appeared to be ill, it was killed, and an ulcer was found in the short segment of duodenum joining stomach and jejunum.

Already in 1898 Chlumsky was reporting somewhat similar experiments in which he threw all the duodenal secretions into the fundus of a gastroenterostomized stomach. His animals did badly and died, perhaps before ulcers could form. He later modified the experiment so as to drain the bile into a loop of jejunum and allow only pancreatic juice to go through the stomach (Fig. 1, *c*). In 1900 he repeated Steudel's work, closing the end of the duodenum and making a gastroenterostomy so that all the duodenal juice would have to go back through the stomach to the jejunum (Fig. 1, *b*). Most of the dogs died after a few days and ulcers were not observed.

In 1910 Moutier made a total gastric pouch in a number of dogs for the purpose of obtaining gastric juice and three of the animals died with a perforated gastric ulcer (Fig. 1 *e*). He made the further

interesting and possibly significant observation that in these stomachs through which food did not pass, the ulcers did not show the usual predilection for the lesser curvature.

In 1914, Kehrer, in fifteen dogs, tied the common bile duct and anastomosed the gall-bladder and the pancreatic ducts with a loop of ileum. (Fig. 1 *i*.) Three of the animals died later with superficial hemorrhagic lesions of the gastric mucosa, and three with definite gastric ulcer. Strange to say, only once did he find an ulcer in the duodenum.

Keppich, in 1921, repeated Chlumsky's experiment of throwing all of the duodenal secretions into the fundus of a gastroenterostomized stomach. In two dogs in which 6 cm. of the pars pylorica was left in connection with the duodenum deep jejunal ulcers formed (Fig. 1 *k*). In two other animals the operation was modified to the extent that much of the distal end of the stomach was resected. In neither of these dogs did an ulcer appear. In two other animals he combined Chlumsky's and Langenskiöld's operations so as to throw the duodenal juices into the fundus of a stomach which emptied through the pylorus, into a short segment of duodenum and then into the jejunum (Fig. 1, *l*). An ulcer did not form. From his work Keppich concluded that a mixture of pyloric and duodenal secretions is more likely to produce jejunal ulcer than are the duodenal secretions alone.

Koennecke, in 1922, tested this theory by isolating the pars pylorica and first portion of the duodenum (apparently above the openings of the pancreatic and biliary ducts), closing both ends and draining this segment into a loop of ileum. The main portion of the stomach was then drained into the second portion of the duodenum as in a Billroth 1 operation (Fig. 1 *m*). Ulcers did not form anywhere. When in addition to this operation he cut the splanchnic nerves on both sides he obtained chronic duodenal ulcers in all four animals. Splanchnicotomy alone rarely produced ulcers. It is hard to interpret these results.

FIRST CHRONIC ULCERS PRODUCED AT WILL

In 1923 Mann and Williamson published the results of experiments similar to the one of Langenskiöld which, for the first time, gave the scientific world a technique which could be counted on to produce, in 95 per cent of the dogs operated on, typical punched-out chronic duodenal or jejunal ulcers similar to those found in men and women (Fig. 1, *s*). They isolated the duodenum by cutting it away from the pylorus and the jejunum. The oral end of the duodenum was closed and the distal end anastomosed with a loop of ileum so as to throw the pancreatic and biliary secretions into the lower part of the bowel. The cut end of the jejunum was then connected with the stomach at the pylorus. In most of the dogs so operated on, ulcers formed in the first few centimeters of jejunum next to the stomach. In some series of experiments ulcers developed in every animal. This experiment and modifications of it have since been performed by surgeons all over the world and with the same results.

COMPARATIVE SUSCEPTIBILITY OF PARTS OF THE DIGESTIVE TRACT TO ULCER

As already stated, a number of investigators have found that experimental ulcers made on the lesser curvature of a dog's stomach heal more slowly than those made on the greater curvature. When Morton drained the duodenum into the ileum, ulcers made along the greater curvature still healed, but those on the lesser curvature became chronic (Fig. 2, *b*). When in the animals with ulcers on the lesser curvature he performed gastroenterostomy, the gastric ulcers healed but a new one formed in the jejunum. Apparently the gastroenterostomy removed some sort of strain from the lesser curvature but it did not deprive the gastric juice of its ability to produce ulcers. In man I have several times seen gastric ulcers which

apparently developed long after the performance of a gastroenterostomy which had served to heal a duodenal ulcer.

According to Jones, and Jones and Ivy, the neutralizing action of hepatic bile and pancreatic juice is probably due to one and the same substance; that is, sodium bicarbonate. The pancreatic secretion however, is a better buffer than is the bile. According to Mann and Bollman, more important yet in protecting against ulcer formation is the neutralizing power of the duodenal mucosa. This is so strong that when the pancreatic and biliary secretions are drained away from the duodenum ulcers formed in only half the dogs operated on.

It has long been known that a Meckel's diverticulum will occasionally contain a patch of gastric mucous membrane which will produce enough juice to make a perforating or bleeding ulcer (see Aschner and Karelitz). This ulcer does not form in the patch of gastric mucosa but in the intestinal type of mucous membrane on its margins. In trying to duplicate this condition experimentally, Matthews transplanted small Pavlov pouches of gastric wall into the ileum and produced the expected ulcers.

Langenskiöld could not satisfy himself that the upper part of the small bowel is more resistant to the effects of gastric juice than the lower part, but much evidence has since accumulated to show that it is. Years ago Matthes showed that the ileum is more susceptible to injury by hydrochloric acid than is the jejunum or duodenum. Later McCann and Ivy and Fauley modified the Mann and Williamson operation, leaving a small segment of duodenum interposed between stomach and jejunum (Fig. 2, *f*). In the animals so treated the ulcers formed in the jejunum, showing that it is more susceptible to injury than is the duodenum, and indicating that this factor of susceptibility is sometimes more important than that of the "motor drive." Mann and Bollman showed a definite gradient in susceptibility to ulcer when they drained the bile and the pancreatic juice into the ileum and then transplanted loops of jejunum and ileum into the usual position of the duodenum. The duodenum was least subject to ulcer, and the ileum most subject. A similar gradation in susceptibility was found by Harper when, with the technique of Goldberg, he found that with a piece of ileum attached to a gastric pouch the ulcer which formed in the bowel perforated about the twenty-third day; with a piece of jejunum the interval was around seventy days, and with a piece of duodenum there was no perforation (Harper) (Fig. 2, *b*).

The rarity with which ulcers occur in the second and third portions of the duodenum suggests that this part of the bowel has a considerable degree of immunity to injury by gastric juice. It is possible however, that if in man the first portion of the duodenum could more easily be excised ulcers would more often be found postoperatively, distal to the line of section. Actually they have been observed in some cases after the Billroth 1 type of operation (Fig. 2, *n*).

After all this experimental work which demonstrates the great susceptibility of the bowel to unneutralized gastric juice, the puzzling, and as yet seemingly irreconcilable fact remains that when bits of gut are used as transplants in the fundus and anterior wall of the stomach, ulcers rarely develop. Perhaps the most extensive experiment along this line was done by Fiori years ago when in six dogs he transplanted a cuff of jejunum or colon into the middle of the stomach much as a plumber might insert a short section of pipe between two others (Fig. 1, *g*). Ulcers did not appear. Apparently, then, some extra factor enters in when the juice leaves the stomach to run into a loop of bowel.

It is a peculiar fact that duodenal and jejunal ulcers are usually found immediately outside the stomach where the mixture of food and acid juice first impinges. The acidity of gastric juice is rapidly lowered as soon as it comes in contact with the bowel but one would hardly expect its

digestive power to be lost before it has gone 4 cm. Actually, Langenskiöld found that the acidity of gastric juice was not entirely lost even after two or three hours of contact with the duodenal mucosa. It will be remembered also that when gastrojejunal ulcers form they are usually to be found in the distal loop which carries food away from the stoma. I wonder if possibly in some cases the duodenal juices fail to bathe the distal loop properly because food from the stomach, entering the proximal loop, tends to block the aboral passage of peristaltic waves. If it were not for an increase in the complexity of the operation the ideal technique for gastroenterostomy might be one in which the jejunum was cut across, the distal end anastomosed with the stomach and the proximal end connected with the side of the distal end 2 or 3 cm. distant from the stomach (Fig. 2, *r*). This would insure the bathing of the danger spot with duodenal juices.

INFLUENCE OF TRAUMA

This was emphasized by Baggio who folded the anterior wall of the stomach so as to make a ridge against which food would rub. He found later that erosions and sometimes ulcers formed either on the summit of the fold or on the posterior wall opposite it. This observation is in agreement with that of pathologists who often find an ulcer on the summit of a benign gastric tumor.

That trauma due to the passage of food over the mucosa is not necessary to the formation of ulcer was shown by the work of Moutier with pouches of the whole stomach (Fig. 1, *e*). It is shown also by the fact that ulcers develop in Meckel's diverticula, away from the current of food, and it has been shown recently by Goldberg and Harper. A few years ago Mann and Bollman found that a fistula into the digestive tract would not leak when they interposed between the stomach or bowel and the skin a short segment of intestine so oriented that peristalsis was directed toward the viscus. When Goldberg and Harper connected such a fistula with a pouch made from the fundus of the stomach of a dog they found that always there appeared a deep perforating ulcer in the bowel adjacent to the gastric mucosa (Fig. 2, *b*). That stagnation of juice is an important factor in the causation of the ulcer is shown by the fact that the lesion does not form if the fistula is made so that peristalsis in the loop is directed toward the skin. Incidentally, this discovery now furnishes investigators with an ideal method for estimating the value of measures designed for the healing of ulcers.

It is hard enough to explain ulcers in the efferent jejunal loop on the basis of trauma and poor neutralization of gastric juice but it is still harder to explain the occasional appearance of ulcers in the gastric side of the stoma.

A curious puzzle in regard to the mechanism underlying ulcer formation in the Mann-Williamson experiment is to be found in the fact that when the distal end of the closed off duodenum is anastomosed with the pars pylorica or fundus so that the pancreatic and biliary secretions have to go through the stomach on the way to the jejunum, jejunal ulcers form almost as often as they do when the duodenal juices are shunted into the ileum (Fig. 2, *e*). This type of experiment, first performed by Chlumsky, Schmilinsky, Enderlen et al., and Keppich has, in recent years, been repeated many times by McCann and by Ivy and Fauley (Fig. 1 *a*, *j*, *l*; Fig. 2, *e*). The failure of the duodenal secretions to protect when they are thrown into the stomach may be due to the curious fact, shown by McCann with fractional tests, that the procedure does not appreciably modify the curve of gastric acidity.

Incidentally these experiments offer no support for the belief of a number of surgeons that cholecystgastrostomy is a good operation for the cure of ulcer. In dogs it is a very bad operation because it leads to infection of the liver and subsequent marked destruction of that organ.

WHAT DERANGES THE NORMAL PROTECTIVE MECHANISM AGAINST ULCER?

The next question is: In the patient with ulcer, what has happened to upset the mechanisms which normally prevent the gastric juice from eating into the mucosa? As yet we do not know, but the research work which has been done now enables us to make some guesses. In the first place many physicians and surgeons have been impressed during the last ninety years with the importance of nervous and psychic factors. A man whose ulcer has been healed, or at least quiescent for years, will perhaps experience some psychic shock; he will be upset by some crisis in his love life or his business, and within a few hours he will be suffering again with hunger pain. I remember well an inventor who was laid low with a gastric hemorrhage every time he received a telegram stating that important machinery on which his income depended had failed under certain tests and would have to be redesigned. The German literature contains references to many such cases, as for instance, to the lawyer who had a hemorrhage every time he tried a case, or to the woman who bled from the stomach when she heard that her husband had been severely wounded at the front.

Those physicians who are inclined to look on the recognition of psychic factors in the production of ulcer as a recent development, dating back at most to the work of von Bergmann, Westphal, Westphal and Katsch, and others in 1913, will doubtless be surprised to learn from Hauser that Siebert wrote on the subject in 1842 and Grünsberg in 1852.

Similarly, those who were interested last year in Cushing's statement that ulcer may sometimes be due to disease in or injury to certain parts of the brain may be surprised to learn from von Redwitz and Fuss (p. 152) that Schiff wrote on this subject in 1846 and that in 1828 Camerer was producing ulcers in rabbits by injuring the vagus and splanchnic nerves.

It is an interesting observation, reported by many pathologists, that ulcer is seen fairly commonly in patients dying with brain tumor. Interesting also is the observation of Robertson and Hargis and others that ulcer is common in patients dying with exophthalmic goiter, a disease which is associated with great irritability of the nervous system. Strange to say most observers have found that in such patients the gastric acidity is lower than normal.

INFLUENCE OF NERVOUS TENSION

Granting that psychic influences are important and that ulcers commonly appear in persons who live under nervous tension, the next question is: How do these nervous influences act? First, there is the established fact that psychic stimuli of a certain type increase the acidity and peptic activity of the digestive juice. Second, it is possible that smaller amounts of the mucus and other protective fluids of the stomach may be secreted. Third, ischemia of the tissues may be produced by spasm of the blood vessels or of the muscularis mucosae or of the main muscular wall of stomach and bowel. Fourth, when it is remembered that the surest way in which to produce ulcers is to shut off the pancreatic and biliary secretions, one must wonder if ulcers are not being produced by an emotional drying up of these secretions similar to the drying of the saliva in the mouth. Fifth, there is the established fact that emotion can produce pylorospasm with stagnation of gastric contents and resultant increase in acidity. Might there not also be spasm and reverse peristalsis in the third portion of the duodenum or first portion of the jejunum producing harmful duodenal stagnation? These suggestions will now be taken up one by one to see what experimental or clinical observations can be brought forward to their support.

It has long been known that the gastric juice of some nervous persons is markedly acid. It has not been so well known that

the amount of pepsin is sometimes greatly increased until it is twenty or thirty times normal. Perhaps the greatest difficulty with the patients with intractable ulcer or with a tendency to the formation of ulcers is that the gastric cells go on secreting acid at times when there is no food in the stomach to sop it up. In many cases the stimulus arises in the ulcer, and the stomach keeps secreting fluid much as an eye keeps watering when the cornea is injured. This is shown by the fact that an ulcer in a Pavloff pouch will cause it to secrete excessively. Similarly, in Harper's experiment, as the ulcer forms in the segment of bowel leading from the gastric pouch, the acidity of the pouch juice progressively increases (Fig. 2, *b*).

In some patients the stimulus may keep coming to the stomach from an overly active and irritable brain. In this connection the extensive work of Stahnke is interesting. He showed in dogs that electric stimulation of the vagus nerves for forty minutes a day for periods of from two to three months resulted in, first, some increase in gastric acidity, second, a marked and often five-fold increase in peptic activity, and third, the occasional production of ulcer.

It is interesting to note also that ulcers can be produced in the stomach of a dog by the manoeuver of sham feeding (Silbermann). The esophagus is brought out in the neck so that the food drops to the floor as soon as it is eaten. Animals of a certain temperament will snap it up again and go on eating greedily for perhaps three-quarters of an hour. The result is a powerful stimulation of the gastric glands; large amounts of fluid of high acid and peptic titer are secreted, and an ulcer sometimes forms in the stomach.

Hemorrhagic erosions and possibly ulcers have been produced also by the giving of toxic doses of pilocarpin, nicotin, neurin and other drugs designed to stimulate the gastric glands by way of the nervous system. It is probable that the bad effects of tobacco on the symptoms of ulcer in man are due to some irritant influence of the drug on the nervous system.

Some persons have wondered if ulcer might not be a sort of Raynaud's disease of the stomach and duodenum. Against this theory is the fact that when Stahnke stimulated the vagus nerves he found that the blood vessels became widened and the stomach redder than normal. It seemed appropriate to him that nervous influences which greatly increase the activity of the stomach should, at the same time, help the tissues to obtain the necessary increase in blood supply.

It is probable, however that many psychic and emotional disturbances affect the bowel also by way of the splanchnic nerves and these might produce a shut-off in circulation. Actually Barcroft has noticed blanching of the mucous membrane of "exteriorized" segments of bowel transplanted into the abdominal wall, and it is still possible that vascular spasm has something to do with flare-ups in ulcer symptoms. Unfortunately as yet no one knows much about the relative importance of the sympathetic and parasympathetic divisions of the nervous system in producing gastrointestinal disturbances. It is doubtful if the drugs that have been used in an effort to distinguish vagotonia from sympathicotonia have any value; the trouble is that most persons who are overly sensitive to one group are overly sensitive also to the other. Much of what has been written on the subject is of doubtful value.

During all his work, Stahnke watched the stomachs of the dogs with the roentgen ray and at no time did he see spasm of the muscle so prolonged that it could conceivably produce ulcer. Other investigators have seen spasm in the muscularis mucosae which they thought might shut off the circulation of the mucous membrane.

There are reasons for believing that powerful psychic stimuli might dry up the pancreatic and biliary secretions. Everyone knows that emotion can stop the saliva from flowing, and the experiments of Beaumont on the stomach and of Mac-

ewen on the cecum have shown that the gastric and intestinal mucous membrane will become dry under the influence of anger or worry. In the case of Alexis St. Martin, fear, anger, or whatever depressed or disturbed the nervous system caused the villous coat of the stomach to lose its smooth and healthy appearance; it became sometimes red and dry, and at other times pale and moist; the secretions became vitiated, greatly diminished, or entirely suppressed, and the layer of mucus became scarcely perceptible.

Suggestive of the presence of pancreatic dysfunction of psychic origin are the pale, bulky, fatty stools sometimes passed by sensitive persons who have eaten under the influence of excitement, fear or anger.

DUODENAL STASIS

He who remembers how commonly nausea and vomiting result from mental impressions will be inclined to wonder if psychic influences might not reverse somewhat the peristaltic trends in the upper part of the digestive tract, at least enough to produce temporary stagnation of gastric contents in the duodenum. His idea would be that such stagnation might possibly upset the mechanisms that protect this part of the bowel from the formation of ulcers. Sloan has reported many experiences which convinced him that not infrequently duodenal ulcer or pseudo-ulcer can be cured simply by loosening adhesions about the ligament of Treitz and thereby giving better drainage to the duodenum. According to Hurst and Stewart (p. 67) duodenal stasis is not infrequently associated with duodenal or gastric ulcer, and Slocumb has collected much evidence to strengthen this contention. Actually, I think the impression of most roentgenologists is that in cases of duodenal ulcer the duodenum tends to empty quickly. Somewhat against the theory that duodenal stasis might favor the formation of ulcers is the fact that they rarely develop during pregnancy when there is much back-pressure in the digestive tube; in fact there are records of cases in which pregnancy seemed to serve as a cure for ulcer.

PRESSURE EXERTED BY THE ABDOMINAL WALL ON THE ULCER

While talking about duodenal stasis as a possible factor in the production of ulcer it may be well to mention the curious fact that many patients with ulcer or pseudo-ulcer are distressed if they bend over so as to put pressure on the organs in the upper part of the abdomen, and they are relieved when they sit upright or bend a little backward. Long ago my attention was called to this when an intelligent man who had suffered for twenty years with ulcer told me that he has been cured by lowering his chair at the office so he wouldn't have to bend over his desk all day. Later I found that some of my physician friends with pseudo-ulcer promptly get pain if when driving an automobile they sit hunched over the wheel. Others get pain if they bend over to weed a lawn. The literature contains many references to this phenomenon, and German writers speak of the frequency with which an ulcer type of pain is met with in tailors, shoemakers, and others who sit bent over at their work.

According to a number of writers, this distress is due to pressure brought to bear by the principal fold of the anterior abdominal wall on the stomach or duodenum. The phenomenon was first described by Rasmussen in 1887 and it was later studied in detail by Hitzenberger and Reich, Rohde, Schwarz and others. It has even been suggested that in women, with their tendency to ptosis, the fold presses on the middle portion of the stomach and causes gastric ulcer, while in men with a high stomach it presses on the duodenum and causes duodenal ulcer.

It is well known to every clinician that lifting or straining is harmful to patients with ulcer. I often tell them that the stomach is like a hammock that hangs from two hooks and one of these hooks contains the ulcer. Obviously, any move-

ment that puts strain on the hook is likely to make the ulcer worse, and I have seen a number of patients in whom lifting promptly brought on a hemorrhage.

PROBLEMS OF TREATMENT

In young patients with ulcer, and in the many patients with pseudo-ulcer the great desideratum is some method of overcoming the predisposition to the disease. Many patients doubtless would be well if they could live an easier life, both mentally and physically, and many could probably get more satisfactory relief through the giving up of ambitions and living simply than they get from expensive courses of treatment in one hospital after another. A few clinicians already know that in some cases they can get as good results with nerve sedatives, soporifics and rest as with alkalies and diet; and the taking of an hour's rest after each meal will sometimes help wonderfully. In cases of pseudo-ulcer a vacation usually works like a charm, and often with real ulcer it will bring about a remission of symptoms.

Active research must be continued to find some method of lowering the digestive power of the gastric juice. One approach to the problem would be through a study of gastric secretion in young persons with achlorhydria. If we could learn something about the mechanism that produces this abnormality we might be able to imitate it in patients with ulcer. So far, fat has been the secretory depressant most widely used by the clinician. It has the double advantage that it lowers acidity and it tends to remain long in the stomach. If it left rapidly its effects would be too transient. I think Glassner's and Hurst's and Stewart's (p. 393) method of giving a little olive oil or some other fat at bedtime deserves further trial and careful study. Much fat cannot be used during the day because it causes nausea.

It has long been known, of course, that the corner stone of any medical treatment for ulcer must be the giving of food at frequent intervals. The explanation usually given to patients is that the food sops up the acid and combines with it. Perhaps even more important is the protective action exerted by absorbed peptones and other food substances on the cells in the mucosa. This discovery of Langenskiöld and Mann and Bollman is of tremendous importance to the clinician who now has even more reason than he had before to urge patients with ulcer to keep food in the stomach.

Furthermore there is every reason now to advise the patient after gastroenterostomy to continue for several weeks with frequent feedings until his gastric and intestinal mucous membranes have lost their sensitiveness to acid and until much of the danger from jejunal ulcer has passed. Actually if we take Mann and Bollman's observations together with those of Palmer on ulcer pain, we can be fairly sure that with some duodenal ulcers and at certain times in every patient with ulcer there is a marked sensitization of the gastric mucosa. It may well be that the presence or absence of this sensitization has much to do with determining whether gastroenterostomy will be followed promptly by the development of a jejunal ulcer.

If I had to submit to the resection of a florid jejunal ulcer I think I would want the surgeon to sew in a catheter with its tip near the stoma and to start immediately with a drip consisting of a solution of peptone. I would want this kept up for a few weeks until the mucous membranes had lost their sensitiveness to acid, and with it, perhaps, most of their susceptibility to recurrent ulceration.

The effects of atropin are usually transient; I have no confidence in them, and often the treatment is more annoying than the disease. Mann has not been able to heal experimental ulcers with it. As Hardt and Rivers showed years ago, the development of alkalosis imposes a limit to the use of alkalies, and as Crohn and, more recently, Harper have shown, there is a strong tendency to a rebound when the acid is forced down by neutralization. In some patients and in many dogs gastric

acidity just cannot be controlled even during the day. Injections of foreign protein, while clinically helpful in some cases, do not consistently lower gastric acidity (Vanzant).

Probably one of the greatest faults of our present method of treating ulcer is to be found in the fact that nothing is done to neutralize the acid secreted during the night. Winkelstein has tried to obviate this by feeding the patient continuously through a small indwelling tube but the discomfort and interference with sleep is often so great that I doubt if the method can ever come into general use.

During the last two years many physicians, following the lead of Fogelson, have been experimenting with mucin, and it is possible that something will come of this work. Unfortunately mucin is not a particularly good buffer for hydrochloric acid, and what little effect it has is apparently due to the peptone which is mixed with it (Jones and Ivy, Mitchell, Vanzant). Moreover, the mucin made thus far has been unpleasant to take and many patients have refused to continue its use. With a better product some of these objections may be overcome.

TYPES OF OPERATION USED

Gastroenterostomy is still the best and most practical operation available for the cure of duodenal ulcer; in eight or nine cases out of ten it works like a charm and the patient is well. Unfortunately in two or three cases out of a hundred the patient returns with a jejunal ulcer, and in an occasional one of these patients a new ulcer will form almost as fast as the old one is excised.

In their desire to protect patients from this danger some surgeons have turned to the operation of subtotal gastrectomy. In Germany, with the complicated type of ulcer that is seen so commonly, this operation is doubtless often the only one that can be counted on to work a cure, but in most of the cases seen in the United States it does not seem right to do such a big operation or one with a risk so much higher than that of gastroenterostomy. It would not be so bad if subtotal gastrectomy would always safeguard the patient from jejunal ulcer, but unfortunately it does not do this. It appears to do it in cases in which an achlorhydria is produced, but unfortunately this object is not always attained even when more than half the stomach is removed. Similarly the Billroth II operation does not safeguard the patient from the formation of a jejunal ulcer (Fig. 2, *o*).

The Billroth I type of operation, or an excision of the ulcer with pyloroplasty does not carry with it the dangers incident to the formation of a jejunal ulcer, but unfortunately these operations can be performed only in certain favorable cases (Fig. 2, *n*). In some cases, also, the relief obtained by the patient is not so complete as it commonly is after gastroenterostomy.

AVOIDANCE OF JEJUNAL ULCER

How can we physicians and surgeons hope to pick out some day the patients in whom an operation and particularly gastroenterostomy had better not be done? I can conceive of at least two ways in which this end might be accomplished: one is through an anthropologic type of study of the individual and his reactions, and the other is through a study of his gastric juice and the way in which it is secreted. For several years we at The Mayo Clinic have been becoming more and more fearful of operating on the keen, nervous, active, hard-living, "go-getter," sales-manager type of man, and especially when he is of Jewish ancestry. The Jew seems to be particularly subject to a severe type of recurrent ulcer, so much so that at Mt. Sinai Hospital in New York Berg and his colleagues have given up the operation of gastroenterostomy in cases of duodenal ulcer and have substituted for it extensive resection of the stomach combined with the cutting of one vagus nerve.

Years ago von Bergmann, Westphal, Westphal and Katsch, and others in Germany worked out a large series of tests which they applied to persons with ulcer to show that most of them have hypersensitive nerves and signs of marked vagotonia, but unfortunately they were not impressed with the need for first applying the tests to a control group of persons without ulcer. The idea back of their work seems to be a good one, and for years I have been trying to get someone trained in the field bordering on physiology, psychology and anthropology to study a large group of persons: some normal, some with nervousness of various kinds, some with pseudo-ulcer, some with easily controlled ulcer, and some with uncontrollable or "dysiatric" ulcer, to see if there is anything peculiar about the nervous and psychic reactions of the persons in the several groups. A particular effort should, of course, be made to see if there is anything distinctive about the physical or mental or nervous makeup of the patient who is highly subject to the formation of jejunal ulcers (Winkelstein).

We may also find some way of recognizing persons highly subject to ulcer through the study of peculiarities in the gastric juice and the ways in which it is secreted. We know, of course, that patients with a high acidity which is not easily controlled by diet, alkalies, or rest in bed are likely to give trouble after any form of operation. But often this criterion fails, and patients with a strong tendency to the formation of ulcers will have only a moderate increase in acidity. Recently Vanzant et al. found that most members of a group of patients with a severe and intractable type of duodenal ulcer had concentrations of pepsin several times the normal. From the point of view of the diagnostician who is often baffled because the distributions of measurements of acidity from normal and diseased persons overlap, the encouraging feature about this work is that while a patient with severe ulcer may have a free acid titer of 60, well within the range of normal variation, his pepsin titer may be 1500 units instead of the 90 which is about normal for an average phlegmatic person.

It might be helpful to study also the reactions of the ulcer-bearing patient to sham feeding, and more might be learned about the mechanisms which cause juice to flow when the stomach is empty.

MECHANICAL FACTORS AT THE PYLORUS OR AROUND THE STOMA THAT MAY LEAD TO THE FORMATION OF JEJUNAL ULCERS

The work of Mann and his students has now made it clear that one of the most important factors, if not the most important in the production of ulcers, at least in loops of intestine draining the stomach, must be a failure of neutralization of gastric juice by the pancreatic and biliary secretions. It has also been shown time and again, both in animals and man, that any form of gastroenterostomy which interferes with the easy access of the duodenal secretions to the mucous membrane about the stoma leads to the formation of ulcers there. The most dangerous of all is gastroenterostomy with von Eiselsberg's closure of the pylorus. In some clinics one out of four patients so operated on has returned with a jejunal ulcer.

The next question is: why should closure of the pylorus lead to such dire results? In the first place, there is the strong suspicion based on the work of a number of investigators, that the gastric chyme is not able to produce so good a stimulus to pancreatic secretion when it comes in contact with the jejunal mucosa as when it is poured normally into the duodenum. Burdenko found in a few dogs with gastroenterostomy, pyloric closure, and a pancreatic fistula that the giving of food produced very little juice: sometimes only a fifth or an eighth of the normal amount, and at necropsy there was an atrophy of the pancreas. Enderlen et al. also made a fistula into the duodenum and found very little secretion there after pyloric exclusion.

The next possibility is that with the closure of the pylorus the small amount of

pancreatic and biliary secretion which is poured out is not pushed on into the jejunum. Years ago Wheelon and Thomas, and Mahoney and I showed that the peristaltic waves that sweep material through the duodenum usually start about the time that a little chyme is pushed through the pylorus by a gastric wave. There is reason to believe, then, that duodenal peristalsis should be weakened by closure of the pylorus and particularly by a complete separation of stomach from duodenum; actually there is experimental evidence to show that this does happen (Enderlen et al.). Enderlen and his coworkers found that the juices stagnating in the duodenum after pyloric closure not only possess great digestive power but their presence serves to prolong the third, or intestinal phase of gastric secretion. Obviously, this is highly undesirable.

Theoretically, duodenal peristalsis ought to be more nearly normal when the surgeon cuts the stomach across about 12 cm. above the pylorus so as to leave the powerfully muscled gastric antrum in connection with the bowel, and actually Balfour tells me that this operation, used by Kelling, Denk, Devine, Balfour and others, is seldom followed by jejunal ulceration (Fig. 2, *p*). That it does not absolutely protect the patient against this mishap is shown by Denk's report of two cases seen in his clinic.

Theoretically, one of the surest ways of producing a jejunal ulcer should be to close the pylorus and make a duodenal fistula, and actually, this undesired result was obtained when these operations were done on a patient whose case has been reported by Schostak. Following appendicitis the woman had a cecal fistula through which the contents of the duodenum later discharged. In order to close this fistula, gastroenterostomy was done and then a pyloric exclusion. Within five weeks after the gastroenterostomy was performed the patient began to suffer with the pain of a jejunal ulcer which soon perforated.

The next question to arise is: if a man-made pyloric closure so commonly leads to abnormal pancreatic and duodenal function with resultant production of jejunal ulcer why shouldn't the pyloric closure which is due to the presence of a large sclerosing ulcer produce equally bad results? Why shouldn't the surgeon be particularly fearful of performing gastroenterostomy in the presence of a closed pylorus? The need for a clear-cut answer to this question is so obvious that I cannot understand why some surgeon has not long since given it to us. Perhaps someone has, but in months of reading I have not yet run onto any paper in which sufficient data have been analyzed from this point of view.

The lack of curiosity on this point seems to be due to the surgeon's conviction that he gets his best and happiest results from gastroenterostomy in men who have suffered for years with an obstructing type of ulcer. There being no question about this fact, let us see if it can be accounted for in any way. Eusterman's impression is that the best results are obtained in older men in whom the obstructing ulcer has more or less burned itself out and in whom the gastric acidity is not as high as it used to be. He suggests also that, with a gradual closure of the pylorus, some adjustment may take place which, later, when gastroenterostomy is done, serves to protect against the formation of jejunal ulcer.

According to von Redwitz and Fuss it is the young patient with a florid ulcer and pyloric obstruction who gets a jejunal ulcer after gastroenterostomy. Denk also has commented on the danger of performing gastroenterostomy in the presence of an active ulcer and pyloric obstruction. In Schwarz' abstract of 130 cases of gastrojejunal ulcer I find mention of pyloric stenosis in eighty-three; in one case pyloric exclusion was done, in thirteen the lesion was a duodenal ulcer, in eleven it was a gastric ulcer, and in twenty-two no details were given. These data are suggestive, but unfortunately Schwarz did not supply

information about a control group of patients with pyloric stenosis who after gastroenterostomy did not succumb to jejunal ulcer. Actually, we must expect to find most patients with pyloric stenosis escaping gastrojejunal ulcer because we know that three out of four with complete, man-made, pyloric exclusion escape.

The question is: Is the danger large enough so that surgeons should take pains to avoid it? One would expect the pyloric closure due to scarring to be less complete than that produced intentionally by the surgeon, and possibly a small amount of chyme trickling into the duodenum is enough to maintain pancreatic function and duodenal peristalsis. Possibly the surgeon should imitate nature, and when he closes the pylorus he should leave a small hole. Perhaps in every case of obstructing ulcer in a fairly young tense person with high acids he should try to make, in addition to a gastroenterostomy, some sort of an opening between stomach and duodenum.

Obviously, of course, pyloric closure cannot be the only cause of jejunal ulceration because this complication occurs occasionally when gastroenterostomy is done for gastric ulcer or for no ulcer at all.

Eusterman's impression from a large experience is that in most cases the pylorus opens after the ulcer heals, and he doubts if gastrojejunal ulcers are more frequent in the cases in which stenosis persists. I believe, however, that it would pay someone to investigate this point statistically and with great care.

The fact that in some cases gastrojejunal ulcers tend to recur every time they are excised indicates strongly that the cause is not some defect in technique or some peculiarity in the behavior of a particular stoma or of the loops fastened to it because one would not expect these same accidents to occur with every operation. What seems more probable is that either some patients are highly susceptible to the formation of ulcers or else the fact that a jejunal ulcer has been present predisposes to the formation of another. What we need greatly is some answer to the question: why, in some patients does the concentration of acid in the stomach remain high after gastroenterostomy and even after subtotal gastrectomy?

TREATMENT

One hint in regard to treatment has come from several of the men who during recent years have been studying experimental ulcer. As I pointed out early in this paper, many laboratory workers discovered years ago that when in dogs they snipped out bits of gastric mucosa the defects healed rapidly. When Ferguson tried this in rabbits he found that some of the lesions were converted into chronic ulcers and he assumed that this was due to the constant presence of rough food in the stomach (Fig. 2, *d*). Other observers found a difference in the rate of healing of experimental ulcers depending on the smoothness or roughness of the diet, and on several occasions experimenters have lost dogs because a piece of celery or turnip poked a hole through the floor of an ulcer (Mann, McCann, Bollman). In some cases hair swallowed by the animal has served to retard healing (Bollman, Pappenheimer and Larimore).

As Mann and others have shown, when an ulcer begins to heal, the defect is covered by a layer of epithelium one cell deep. It does not take much rubbing to remove such a membrane, and it becomes obvious that whatever other qualities an ulcer diet should possess, it at least should be smooth and free from rough indigestible particles.

As I said before, experimentation suggests that more work should be done with fats and oils in the treatment of ulcer. They have been used particularly by Glaessner and Hurst but unfortunately they tend to produce nausea and hence there are limits to their use during the day. They might, however, be used at night when they are most needed to inhibit secretion.

SUMMARY

A review has been made of many observations made in the clinic, the operating room, and the laboratory, all of them throwing light on the mode of causation of peptic ulcers and on the ways in which such ulcers should, perhaps, be treated.

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THE NON-SURGICAL TREATMENT OF PEPTIC ULCER

WITH A CLINICAL CONSIDERATION OF THE RELATIVE THERAPEUTIC VALUE OF GASTRIC MUCIN*

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ACCURATE data respecting the results of non-surgical management of peptic ulcer are difficult to secure. One of the chief reasons for this dilemma is that we are not possessed of means whereby, for the individual patient, it is possible to estimate how great is that patient's natural tendency to heal. Thus it happens that so-called "absolute cure" of an ulcer may have resulted spontaneously and would have taken place irrespective of what non-surgical regime had been carried out. That spontaneous healing is not uncommon is proved by the frequent demonstration of healed ulcers at autopsy in patients who never had been aware that ulcer existed or, if they had been chronic dyspeptics, they had accepted the condition and had treated distressing symptoms by simple home remedies or with the aid of advertised medicines. Before the advent of exploratory abdominal surgery and the roentgen ray, and the popularization of peptic ulcer through lay and medical press, patients, though familiar with the discomforts accompanying gastric or duodenal ulcer, were not acquainted with its possibilities as a disease entity. They, as not uncommonly now, came to the physician for the complications of ulcer, particularly obstructions, massive hemorrhage, perforative attacks or malignancy. Sufferers they were, but when it is recalled that barely 21 per cent of *all* peptic ulcers are accompanied by stenoses or the dramatic accidents of gross hemorrhage, perforation or malignancy, one readily may understand how, with such low percentage of mortality even in the presence of chronic morbidity (fortunately, usually, intermittent), years of discomfort are endured with relatively little incapacitation, physical or economic. Ulcer subjects under my care have experienced ulcer-types of dyspepsia for an average of eleven and one-fourth years and yet fewer than 17 per cent are incapacitated or present signs of malnutrition. Often enough, the ulcer itself causes little discomfort, but bowel irritability, a complaining appendix or a sluggishly functioning gall bladder cloud the ulcer picture. When discomfort thus is localized, pain or fear lead to the examination at which ulcer is discovered. The publication of the observations of surgical pathologists concerning the relationship of gastric ulcer and gastric cancer exerted a more powerful influence towards bringing chronic ulcer-dyspeptics under medical care than did the actual discomforts and serious complications of the ulcers themselves. While this result has been a means of aiding sufferers, yet the significance of this desired state upon the healing of ulcer lesions still requires proof. Many physicians and pathologists are well aware that physical comfort does not mean that the lesion of which peptic ulcer is a manifestation has healed: all too often, one observes serious hemorrhages or fatal perforations in patients who were, until the catastrophe, absolutely symptom-free.

Medical statistics of ulcer cure are handicapped by the improper selection of material for treatment. We are acquainted with few statistics which detail the results following non-surgical management of duodenal ulcer, as distinct from those of gastric ulcer. Neither are we familiar with records which list, separately, the results of non-surgical procedures with respect to

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calloused, recurrent ulcer, ulcer producing crater deformity, free-bleeding lesions, ulcer with perforation, or (with the exception of ulcers in syphilis), ulcer accompanied by true organic stenosis.

Twenty-eight years ago, Ewald[1] refused to make statements respecting how often his non-surgical management had cured peptic ulcer. However, he reported in 1919 that Schultz had followed up 299 instances of the affection (all of which had been accompanied by gross hemorrhages) and from 157 replies had estimated that permanently good results had followed in 64 per cent. In 23 per cent the treatment was a failure and there was a mortality of 7.4 per cent.

In 1912, Friedenwald,[2] reporting upon 107 indiscriminately selected patients treated by the v. Leube and Lenhartz methods, stated that, for a five-year period or longer following treatment, an average of 75 per cent remained cured.

I have endeavored to secure information relative to the percentage of permanent cures following the v. Leube-Sippy regimen. There has been published no report stating definitely the status of treated ulcers at periods of, say three, five, seven or more years following treatment. One must be content with Sippy's unqualified but indefinite statement[3] that in "approximately 85 per cent of all cases of pyloric obstruction due to peptic ulcer, 'obstruction' disappears during the first two or three weeks under the influence of the medical treatment advocated. In the remaining 15 per cent of cases 'obstruction' is due to tissue narrowing. If the medical management described is accurately applied the 'obstruction' can be made to disappear in about one-half of these cases also." Sippy further stated that "70 per cent of the instances which were managed were the 'obstructive' type of ulcer."

More recently, R. Brown[4] has analyzed the end-results in peptic ulcer from the services at the Presbyterian Hospital, Chicago (1912–1927) inclusive). His report concerns 1224 traceable patients (75 per cent males and 25 per cent females). The ulcers were duodenal in 923 patients and gastric in 77 patients and both in 12 patients. Brown uses as a criterion of "cure," "a present status of freedom from symptoms," admitting, however, that relapse is possible in certain patients. In his series, 49.5 per cent report themselves as cured, 16.7 per cent satisfactorily improved, or a total of 66 per cent experienced good results following non-surgical management. An additional 10 per cent experienced moderate improvement, while, in 20 per cent, medical treatment failed. Brown's statistics are in close accord with those reported by Ewald, twenty-six years previously.

In our own experience,[5] employing the "physiologic rest" regime developed in my clinic (excluding from the statistics patients who had been discharged from treatment *two years or less*) of 470 patients, cessation of the ulcer process occurred in 361 or 77 per cent. Of 66 patients who came to laparotomy for numerous intra-abdominal lesions, following institution of our ulcer management, completely healed scars were demonstrated in 54, approximately 82 per cent. In the remaining 12 patients, malignancy, perforation, multiple ulcerative or active benign ulcer lesions were present. Such results definitely prove that peptic ulcer can heal if given opportunity equal to that which the surgeon gives stomachs upon whom he has performed resection, excision or enteroanastomosis. Roentgen proof of healing was shown in 94 cases by disappearance or lessening of ulcer deformity, by improved gastric emptying rate, by disappearance of local ulcer tender areas on palpation during fluoroscopy, and by absence of the inferential, motor phenomena characteristic of active ulceration.

For no proved reason, it has been assumed that non-surgical treatment favorably affecting gastric ulcer similarly influences the duodenal lesion. Controlling gastric chemism from the standpoint of neutralizing the free HCl of gastric juice

has been thought an adequate measure for duodenal ulcer healing. My "physiologic rest" regime of management goes further than controlling the free HCl of gastric juice, in that it attempts to place the ulcer-bearing area of the duodenum in a state of peristaltic rest, and thus favors tissue repair.

Very recently, Jordan and Kiefer[6] have reported upon the end-results when duodenal ulcers have been managed by the v. Leube-Sippy routine. These workers conclude that 46 per cent of duodenal ulcers so treated will have one or more recurrences within five years after "cure" (controlled from the standpoints of clinical comfort, laboratory tests and roentgen studies) has been brought about. The greatest frequency of recrudescence is within two and three years after treatment. Failures are manifested by massive hemorrhage, obstructions, epigastric distress and tenderness, reappearance of high gastric acidity and radiologic anomalies. Hinton[7] draws similar conclusions from a review of 324 duodenal and gastric ulcers and states that "any attempt to call a patient cured after either medical or surgical treatments, unless followed for a ten year period and frequently examined, is most misleading."

MUCIN THERAPY

In an attempt to increase the efficacy of non-surgical management of peptic ulcer (gastric and duodenal) during the past two years, and, under the inspiration and guidance of Ivy and his associates, Fogelson[8] has treated patients with a powdered gastric mucin prepared from hogs' stomachs. In published reports, Fogelson and others have dealt alike with gastric and duodenal ulcers and have not considered it necessary to treat these lesions as separate entities. Fogelson's non-surgical peptic ulcer management concerns itself largely with rendering the "corrosive action" of gastric juice innocuous by emplying gastric mucin as an "antacid," a "buffer" or as a local protectant to injured visceral lining. Fogelson (1930)[9] claims that 1 gm. of mucin will combine (and neutralize?) with 12 to 15 c.c. of N/10th HCl. He claims further, that his gastric mucin has a very low secretagogue content and does not stimulate gastric mucosa more than do other bland substances. He states that the preparation has no deleterious systemic effects, has no significance upon gastrointestinal activity, causes neither constipation nor diarrhea, is digested in the jejunum and, in the presence of free HCl, is precipitated and thus becomes effective as a mechanical protectant of injured visceral mucosae.

In drawing these conclusions, Fogelson avails himself largely of the investigations of Ivy[10] and Kim[11] and of Whitlow.[12] The former's researches demonstrate the resistance of mucin (as found in stomach pouches) to penetration by free HCl and to the apparent value of fed mucin in preventing certain animals with biliary-tract fistulae from postoperatively developing "spontaneous" duodenal ulcers. Whitlow's work tended to prove the theory that the reason why the stomachs of living animals are not "auto-digested" is because of the property of mucin, freshly metabolized and excreted, to resist the penetration (and thus, digestion) of free HCl-pepsin. While Whitlow's studies deal largely with test-tube set-ups designed to mimic gastric digestion, yet he showed that, in the living animal, when the mucous membrane is robbed of its "protective" layer of mucin, it is readily attacked by free HCl and pepsin and "digested." However, Whitlow fails to present histologic material in support of his contention that swabbing away mucus from mucosae leaves normally intact and functioning epithelium.

Employing gastric mucin, exhibited *per os*, with or without food, during 1930–31, Fogelson[13] states that he treated 113 instances of peptic ulcer, of which number 56 were in the group of "intractable" ulcer. Sixteen of these patients had experienced massive hemorrhages. In the 56 patients with ulcer of this type, Fogelson reports that 49 patients (87 per cent) were

given "complete relief from all symptoms" and were returned to "economic fitness." He further states that of the entire group of 113 patients (including the 56 "intractable" instances) there were "only 7 failures" and these failures were in the group classed as "intractable." In other words, of all the ulcer subjects treated, approximately 94 per cent were considered cured. Fogelson states further that since February, 1931, approximately 200 ulcer patients have been treated with his gastric mucin in "clinics outside of Chicago," "with 90 per cent relief of all symptoms." The relative occurrence of duodenal and gastric ulcer is not given. Although in selected instances favorable alterations in roentgenographic deformity following treatment are reported, Fogelson's main criterion of "cure" rests upon cessation of symptoms and of constitutional improvement.

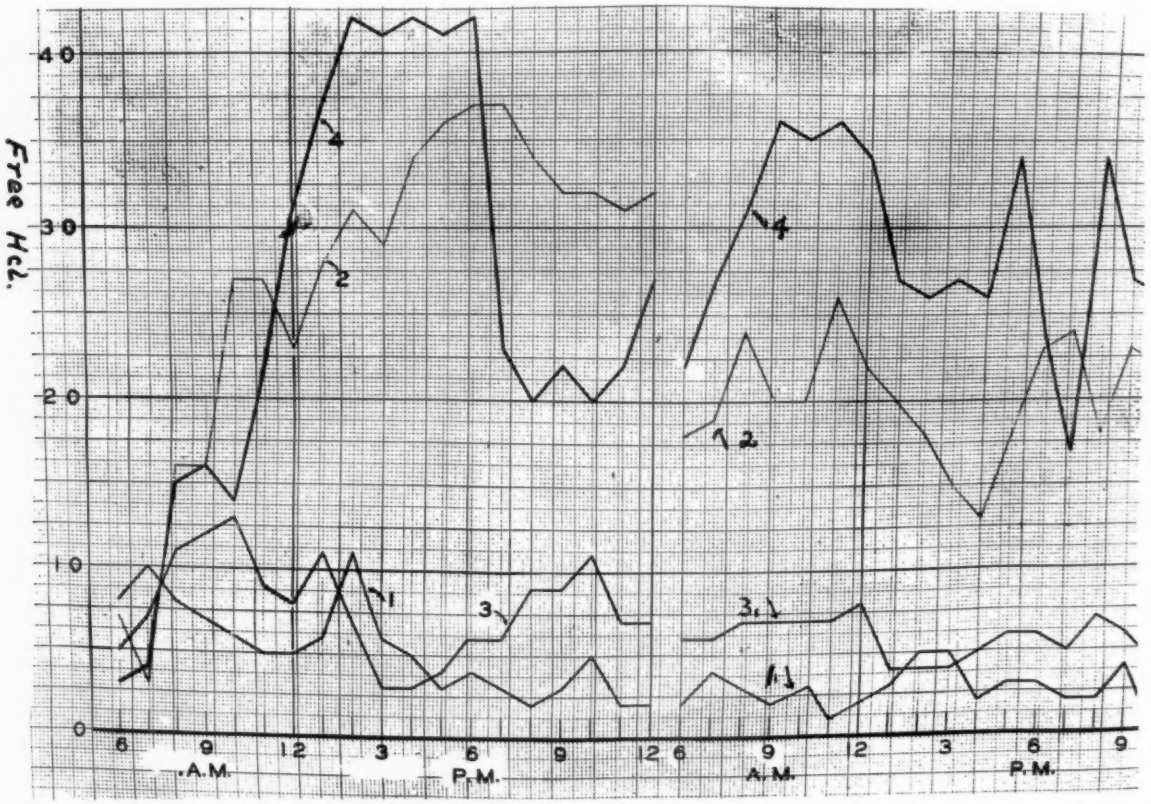
Recently, Atkinson[14] reported the results of mucin management in 43 individuals. His table only vaguely indicates the locations and types of the ulcers. In 18 patients the progress was followed by roentgen observations. Atkinson noted early relief of pain, of abdominal distress, of eructations and regurgitation and, roentgenologically, less visceral spasm and palpatory tenderness together with changes in contour. His studies of the gastric juice demonstrate that when patients were receiving mucin, the relief of symptoms bore but slight relationship to the lowering of free HCl and that the "neutralizing" or "buffering" action of mucin bore little quantitative relationship between the amount of mucin exhibited and the free HCl values of the gastric extracts. Although favorably impressed with the therapeutic value of mucin, Atkinson is non-committal with regards the worth of the preparation towards permanent cure of the ailment. In addition to receiving mucin, Atkinson's patients were on rigid diet, had rest and general care and seemingly, at times, alkali medication.

C. F. G. Brown[15] reports upon 93 patients affected with gastric or duodenal ulcers whom he has submitted to mucin therapy. He states that all his patients definitely improved subjectively and objectively on hourly feedings, general care *and* mucin. He believes that mucin management is responsible for the disappearance of pain, lessened gastric emptying-time, early cessation of bleeding and for favorable roentgen signs. Mucin only partially and irregularly affected free HCl, a transient increase commonly being followed by a lowered reading. The persistence of free HCl bore no definite relationship to the symptomatic improvement. Brown reports no control series but observes that 36 patients who had been unsuccessfully subjected to various types of non-surgical management (chiefly the Sippy regime), not including mucin, were subjectively and objectively relieved when later mucin therapy was introduced.

BIOCHEMISTRY OF MUCIN

Gastric mucin belongs to the group of "compound proteids," in the subgroup "glycoproteids." On cleavage, it yields a protein and a carbohydrate, or an acid allied thereto, but no xanthin bodies. The substance is a colloid and forms a ropy or mucilaginous mixture on attempted solution. Gastric mucin has a composition similar to that of the mucins of saliva or of connective tissue but certain poorly understood molecular arrangements make this mucin different in combining-power. When split with free HCl, acetic acid appears: strong acids break it into leucine and tyrosin. Dilute alkalies produce from it an alkali-albuminate similar to albumose or peptone in structure and reactions (Hammarsten[16]). Strong acids (25 per cent HCl) precipitate mucin and this precipitate is maintained by excess water. Pepsin has little effect upon mucin, except, perhaps, after it has been precipitated by strong acid. Trypsin readily digests gastric mucin leaving available for resorption, after the action of succus entericus, end-digestion products (amines, as tyrosin, leucine) and a carbohydrate

body (or its derived acid) which probably is stored in body tissues as glycogen. It is said (Hammarsten) that an accumulation



Curve 1. Showing, by fractional analyses, the variations in secretion of free HCl in stomach of patient with gastric ulcer under various digestive stimuli. 1, HCl secretion with subject on smooth, non-retention diet; 2, on milk, egg and cream feedings; 3, on milk, egg and cream feedings with alkali exhibited; 4, on milk, egg and cream feedings plus 180 gm. gastric mucin over a twenty-four hour period. (Author's observation.)

of these end-digestion products *binders tryptic activity*. It is apparent that mucin is a substance of definite potentialities as a food, whether or not it serves as an "antacid," a "buffer" or a mechanical protectant to injured visceral mucosae.

PHYSIOLOGIC EFFECTS OF MUCIN INGESTION

When a "mucin meal" (75 — 100 gm. in watery suspension) is fed to the normal, empty stomach, gastric analysis returns a free HCl curve comparable to that returned when a roast beef sandwich has been eaten (Curve 1). Even should the gastric mucin-meal pass rapidly from the stomach and be cleaved in the upper intestine, the mechanical stimulation to the stomach plus the resorption of polypeptids and amino acids excites definite gastric secretion of histamine-like character, e.g. a *gastric juice in which free HCl is abundant while pepsin and nitrogenous bodies are relatively low* (Babkin[17] and Webster[18]). This type of gastric-juice response has been emphasized by Rivers, Vanzant and Essex[19] but ascribed by them to histamine-like impurities in Fogelson's gastric mucin as commercially marketed. I suggest that it is possible that such exist as split-products of mucin when gastric mucin is given therapeutically, and that here may lie an explanation of why certain favorable effects possibly may follow: *its presence (or its end-products) in excess may produce a continuous flow of an acid gastric juice, but a gastric juice of extremely low, or, when prolonged mucin exhibition occurs,*

absent, peptic power (the qualitative "histamine-produced" gastric juice of Babkin). In such circumstances, constant "corrosive," acid-pepsin attack upon damaged visceral mucosa is not possible or is lessened. The excess of split-protein products in the *duodenum and upper jejunum* likewise may interfere with tryptic attack upon injured duodenal mucosa (Hammarsten).

The researches of the Montreal physiologists upon the qualitative variations in gastric juice accordingly as that secretion is brought on by intragastric (hormonal) stimulation or by the "trophic" or nervous (vagal) route, would appear to lend support to my explanation of the manner in which favorable effects may accompany mucin therapy. Pleasant odor, attractive appearance, delectable taste or the physical character of food as served and eaten are the avenues through which "trophic" stimulation of gastric juice travels. Gastric juice *so secreted* has a peptic value 15 to 40 times of that resulting from *intragastric* or hormonal (histamine-like) stimulation. As commercially produced and when clinically administered *per os* (alone or with food), no impartial observer may claim that gastric mucin excites the pepsin-rich "trophic" flow of gastric juice. Many peptic ulcer patients are of highly organized nervous make-up. Their gastric secretions often are continuous (gastrosucchorrhea) during an entire day, and are rich in acid and the peptic enzymes ("trophic" secretion). It is of interest to observe, in passing, that in none of our patients of this "nervous" type was the exhibition of gastric mucin, therapeutically, accompanied by satisfactory clinical results. Further, in reference to the *qualitative* aspects of gastric secretion, it is common knowledge that when patients are affected with constant nausea (non-obstructive in origin), gastric juice is low both in acid and in peptic activity. In such patients, apparently *vagal* stimulation is weak. It is interesting to observe that when ulcer patients have a constant repugnance to taking gastric mucin, not infrequently clinical benefit follows, a benefit not wholly ascribable to the limited food-load to which the stomach is subjected,or to the buffer or protective qualities of mucin.

Since the secretion curves which Fogelson, Atkinson and C. Brown have exhibited, and our own observations, reveal that the "*reduction*" of free HCl in gastric juice bears little direct relation to the *quantity* of gastric mucin administered, we suggest that apart from any "buffering" or "neutralizing" effect upon the free HCl, gastric mucin may exert the favorable effect claimed by its limitation of pepsin production and by its antitryptic properties (through its end-digestion products).

PHYSICAL PROPERTIES OF MUCIN

Fogelson's "gastric mucin" is a sticky, grayish-white powder, with a somewhat offensive odor which becomes more pronounced when the preparation is moist or not kept cold. In such circumstances, the odor not rarely is fecal. Patients state that the taste of mucin corresponds closely with its odor. Ambulatory patients find it impracticable to preserve the powdered mucin under ideal conditions and hence have a growing repugnance to taking it as a medicine. C. Elliott[21] states that in his experience "it has been difficult to get patients to take it (gastric mucin) unless they were in dire need of clinical relief."

Fogelson recommends that gastric mucin be given intimately mixed with such foods as egg-nogg, chocolate malted milk, cocoa, cream soups, or thin custards. However, it has not been our experience that even when the greatest care was taken, by experts, intimately to "fold in" the mucin with food, the resultant mixture was unattractive in appearance, taste or odor. Often the mixtures are slimy or lumpy, so much so that patients may refuse the feedings and their general nourishment become impaired by partial starvation. Particularly were the preparations poorly borne by patients who experienced regurgitation of gastric contents or who frequently

belched. The odor of these regurgitated or vomited stomach-contents not rarely resembled that present in instances of fecal vomiting caused by high intestinal obstruction. In only five of our patients was gastric mucin taken with little complaint. Eleven patients refused to continue taking the preparation after their initial discomfort had become ameliorated by mucin, diet or general care.

The exhibition of gastric mucin in gelatin capsules proved unsuccessful. The mucin escaped slowly from the capsules and instead of diffusing throughout the stomach contents to act as a "mechanical protectant" or to "buffer" free HCl, it formed tough, slimy "clots." These left the stomach slowly: we have washed them, undisintegrated, from a stomach as long as six and one-half hours following their being swallowed, where no obstructive lesion was present. In 5 instances, mucin capsules, only partly broken down, were recovered from stools as long as thirty hours after being taken per os. Finally, when gastric mucin is given in capsules, in order to exhibit an average dose of 100 gm. a day, an awe-inspiring number of large capsules must be prepared. Gastric mucin is not a cheap preparation, whether put up in capsules or taken from bulk. We abandoned the capsule as a vehicle of administration altogether after a relatively brief trial.

Our experience with Fogelson's gastric mucin as an aid in non-surgical ulcer therapy dates back approximately nine months. At first we employed a preparation supplied by Doctor Fogelson, but later ordered it in bulk by prescription. In all instances, we endeavored to exhibit the preparation according to printed instructions given by Doctor Fogelson to his patients at The Northwestern University Clinic.

CLINICAL EXPERIENCE

For purposes of comparison of our results with those of others, when possible (except in the presence of gross hemorrhage or threatened perforation) in this group of patients, we omitted the customary initial period of total abstinence from mouth-feeding or medication per os which is a characteristic feature of the "physiologic rest" method of treatment. The smooth, preponderatingly carbohydrate diet (outlined by us a decade ago), with small food volumes given, generally warm and frequently, was exhibited. Except in emergencies, medication other than mucin was omitted. It is to be emphasized, as C. Elliott[21] has done, that in their mucin management, Fogelson, Atkinson, C. Brown and others have consistently fed liquid or soft smooth diets and carried out other generally accepted therapeutic procedures while they subjected patients to gastric mucin therapy. Since such has been their routine and since it is well known that peptic ulcers may heal readily when diet alone is controlled, the precise evaluation of the clinical worth of administered gastric mucin practically has been difficult.

MATERIAL

Thirty-nine patients were studied (Table 1). There were no "acute" perforative ulcers; all were "obstinate" (histologically and chronologically) and chronic. No patient was experiencing his first "ulcer management": all had been "cured" from one to as many as 14 times, the average number of "cures" being 4. The average ulcer-type dyspeptic period had been 9+ years, with a minimum of 2½ years and a maximum of 33 years. Recrudescences had averaged, for the group, 8, with a minimum of 3 and a maximum stated as "innumerable." The average quiescent period between ulcer "attacks" was 5¾ months when not under active management supervised by physicians; then it increased to approximately 9½ months. Thirty-one of our patients were adult males, the remaining 8 were females. The age averaged 41 plus years, the range being 20 to 74 years. All were of the white race, approximately 80 per cent being American-born; the others were of foreign

TABLE I

DATA UPON PATIENTS PRIOR TO PRESENT TREATMENT

(a) Unoperated

1. *Ulcer location and type*

Duodenal ulcer, uncomplicated	12
Duodenal ulcer with protected perforation	5
Duodenal ulcer with partial obstruction	2
Gastric ulcer, uncomplicated	4
Gastric ulcer with hour-glass deformity	1
Gastric ulcer, prepyloric with partial obstruction	4
Ulcerated gastric polyposis	1
Total	29

(b) Patients with Prior Operations

2. *Ulcer location and type*

Plastic surgery (at pylorus) for ulcer	3
Gastro-enterostomy followed by gastro jejunal ulcer	5
Partial resection followed by ulcer at anastomosis	1
Gastro-enterostomy and recrudescence of old ulcer	1
Total	10
Grand total	39

3. *Miscellaneous Data*

Massive hemorrhage in	7
Average duration of entire ulcer history	9+ years
Patients having had previous "cures"	39
Surgery in addition to medical "cure"	10
Average number of non-surgical "cures" per patient	4
Average recrudescence interval when not supervised by physician	5¾ months
Average recrudescence interval under supervision	9½ months
Previous hospitalization (37 patients) averaged during "cures".	6+ weeks

4. *Age and Sex*

Female patients	8	
Male patients	31	
Average age: females	44	years
males	39	years
whole group	41+	years

5. *Roentgen Study*

Duodenal ulcer	Positive signs	26
	Inferential evidence	3
Gastric ulcer	Positive signs	9
	Inferential evidence	1
Gastrojejunal ulcer	Positive signs	3
	Inferential evidence	1
	History plus localized tenderness or fixation	1
Pyloroplasty: Positive signs in		3
Gastric polyposis: ulcerated multiple deformity		1
Partial gastric resection plus anastomosis		1

birth or extraction. The majority of our patients was in relatively easy, middle-class circumstances from substantial homes; none was destitute or of the usual dispensary class. Except when special observations were desired, test-meal data were secured after the exhibition of full mixed-meals. For more than seven years, in my clinic, no Ewald-type meals have been employed chiefly because I have not considered such a preponderatingly *carbohydrate* meal of small volume an adequate test for *peptic* digestion or for gastric motility.

Of the group, 10 patients had been subjected to one or more operations for the relief of duodenal or of gastric ulcer. Seven (17+ per cent) had experienced massive hemorrhage; 4 were bleeding when they came under treatment.

Of the 39 patients, 27 (70 per cent) were hospitalized or were bed-patients in their homes. Instead of the relatively high protein, acid-stimulating diet of Sippy, liquid and, later, soft and smooth, high carbohydrate, non-acid-stimulating, small frequent meals were given. We can find no reason for feeding food demanding acid and pepsin for its digestion should the object of diet in peptic ulcer be the control of free HCl.

Twelve patients (30− per cent) were ambulatory; either they did not feel sufficiently ill to take treatment in bed or, economically, they could not afford to stop work. None of this group had experienced massive hemorrhage.

RESULTS OF TREATMENT WHEN MUCIN IS EXHIBITED

Table II gives essential data relative to treatment and results and compares or contrasts the effects of ulcer treatment with mucin with those following the v. Leube-Sippy treatment and our regime of "physiologic rest."

Upon reviewing (Table II) the condensed summary of our experience, clinically, with mucin and upon comparing the results of mucin management with published records

of peptic ulcer behavior under other regimens, one is forced to conclude that the mucin treatment leaves much to be desired. Certainly, at our hands, this mode of therapy has not lived up to the expectations which had developed from the reports of Fogelson and of C. Brown.

It is granted that our experience has been brief and only a small group of patients has been treated, but these handicaps can be discounted since all the published work of the mucin proponants emphasizes the shortness of time requisite for the preparation to produce striking relief.

"Toxic" effects of gastric mucin have not been mentioned by Fogelson, Atkinson and C. Brown; in fact, it has been stated that gastric mucin caused no untoward signs or symptoms. Osgood[20] has stated that toxic symptoms may occur. Our experience has not supported this. Cases No. 9882 (gastrojejunal ulcer), 4934 (recurrent peptic-gastric ulcer with old gastroenterostomy), 9748 (chronic duodenal ulcer), 10,098 (lesser curvature, chronic ulcer), and 10,215 (ulcerated gastric polyposis) experienced definite ill-effects following the exhibition of 120 gm. of mucin daily. The disability appeared within an average time of three days (range, sixteen hours to five and one-half days). The patient felt weak ("all in"), and "queer," was listless but irritable and complaining on attempts to talk with him or carry out daily care; had light-headedness and slight mental confusion; sometimes vision was "blurred"; the face and body skin appeared pale and was cold and usually moist. Pulse was of low volume and rather frequent; the temperature at first tended to be subnormal but with ten to twelve hours increased 1 to 2°F. The blood pressure fell 10 to 25 points (mercury manometer). Nausea was a pronounced symptom and several patients vomited, 2 to the point of exhaustion and dehydration. Attempts to continue mucin administration aggravated the condition so that, in 3 patients, general stimulation became necessary (caffein sodium-benzoate, hypodermatically, external heat and rectal feeding). Disability lasted several days. Gradually, as mucin was omitted from the management, the condition was restored to that prior to the appearance of toxic symptoms and signs. In character, this toxic phase of gastric mucin treatment resembles what follows in patients who have passed through an acute mild protein shock or are convalescing from an acute, severe "bilious" attack. Our knowledge of the channels through which gastric mucin becomes operative toxically is incomplete. We have had no adequate opportunity to study the blood chemistry or the urine during the toxic phase. One is rather inclined to the opinion that when gastric mucin is not well borne, there occurs deficient protopexic function of the liver, so that partly-split mucin or excess amines pass through into the circulating blood. What the effect of mucin upon the digestive efficiency of trypsin and of *succus entericus* is, it is not possible to state, though this should be considered. In such circumstances, where there is excess of amines there occurs resemblance to the status present in high intestinal obstruction.

The daily dosage of mucin was, with the limitations stated above, approximately 120 gm. For the first week of management, although not without much urging and diplomacy on the part of nurses, such dosage commonly was possible. Since it is during the first few days that improvement has been stated as being so startlingly striking, even when after a week patients rebelled and less mucin was exhibited, our results are comparable with those of other clinicians. Early, it became apparent that inasmuch as disappearance of free HCl bore but casual relationship to the quantity of mucin given and since no one has advanced work proving how much mucin is required to "control" the free HCl in health or disease, it appeared that dosage was largely empirical. In peptic ulcer, as is true also for the normal healthy adult, the total quantity of gastric juice secreted in twenty-four hours varies greatly.

Accuracy of dosage would appear to call for an observation-period on each patient during which his volume-output of gastric juice and incidentally his free HCl are calculated. Otherwise, the daily dosage is but guessed at, just as at present is the quantity of alkali administered in the v. Leube-Sippy management. If, as is believed, gastric mucin acts as an excessive histamine-like stimulus and produces a pepsin-poor (or absent) gastric juice, it is likely that revision downward of dosage will be required. At any rate, we feel that there remains much to be done before accuracy of dosage for the individual can be determined. On account of the possibility of "toxic" effects with mucin, it is our belief that excessive dose, with its dangers of large amine (or derivatives) accumulations in the upper jejunum should be avoided.

With our patients it is interesting to note that limitation of the supply of mucin to 20 to 30 gm. daily (in 2 patients,

TABLE II

COMPARISON OF RESULTS OF NON-SURGICAL MANAGEMENT OF PEPTIC ULCER

Data on Patients	Mucin Therapy[14] (Author and Atkinson)	R. Rrown's[4] Data for v. Leube-Sippy Management (Continuous Alkalization)	"Physiologic Rest" Regime (Author[5])
Average days in hospital.....	4.3 wks. (Atkinson 3.1 wks. 8 cases)	No statement follows treatment	3.7 wks.
Days constantly in bed.....	13 days (Atkinson, Fogelson not stated)	No statement follows treatment	9 days
Pain controlled, average.....	6+ days (Atkinson, "2nd or 3rd day")	No statement follows treatment	40 per cent in 24 hrs. 81 per cent in 3 or less days
Bleeding stopped, average.....	7½ days (Atkinson, "no longer than 9 days")	No statement follows treatment	92 per cent within 5 days
Nausea stopped.....	5 days (Atkinson does not state)	No statement follows treatment	1.5 days
Vomiting stopped.....	3 to 4 days (Atkinson, "almost immediately")	No statement follows treatment	18 hrs.
Abdominal tenderness absent..	5 to 9 days (Atkinson, not stated)	No statement follows treatment	2 to 5 days
Blood improvement began.....	6 to 10 days (Atkinson, not stated)	No statement follows treatment	2 to 5 days
Symptom free.....	6 to 15 days (Atkinson, 1.7 days)	No statement follows treatment	96 per cent within 3¾ days
Acid control.....	Irregular in relation to clin. picture (Atkinson same)	No statement follows treatment	1 to 4 days
Favorable roentgen films.....	18 cases (49 per cent) (Atkinson, 18 cases all improved)	No statement follows treatment	68 per cent
No change in roentgen films...	15 cases (39 per cent) (Atkinson declares none)	No statement follows treatment	14 per cent
Unfavorable roentgen films....	6 cases (15 per cent) (Atkinson: "none has larger niche or more spasm")	No statement follows treatment	18 per cent (stenoses: large scar, etc.)
Effect on time interval of recrudescences	Apparently to be lengthened (Atkinson does not state)	No statement follows treatment	From average interval of 9½ mos. to average interval 32 mos.
Recrudescences.....	4 cases (Atkinson does not state)	"Approximately 20 per cent"	14 per cent
Present status.....	11 cases (29 per cent) still ill; 28 cases (71 per cent) quiescent but time interval too brief for final opinion (Atkinson noncommittal. C. Brown: "Improved after mucin for 1 year"; 37 cases.[15])	49.8 per cent "cured"; 16.7 per cent "greatly improved"; 10 per cent "improved"	Of 470 patients, 361 (77 per cent) cessation of ulcer process. Of 66 patients coming to operation in 54 (82 per cent) healed scars demonstrated.

10 gm.) allowed 9 patients to remain just as comfortable as previously when they had been taking several times this quantity. Such observation would tend to support my opinion that if gastric mucin exerts any beneficial effect it is due more to controlling *peptic* than *acid* "corrosion." With regard the "protective" effect of gastric mucin, it is sufficient to say that no one has shown experimentally, at laparotomy or autopsy how much gastric mucin is required to "coat" an ulcer base to protect it from proteolysis or that mucin "coating" *ever* occurs.

While *the results of treatment* are detailed in Table 11, several observations require emphasis. Under mucin therapy, our hospital patients required incarceration considerably longer than is stated by Atkinson as his experience and slightly longer than when managed by my "physiologic rest" regime. It is unfortunate that from neither the reports of the late Doctor Sippy and of his colleague R. Brown, statements are made regarding how long treatment lasts or how the patients fare while undergoing "continuous alkalinization" management. They give only data respecting end-results. Upon mucin exhibition, Table 11 shows that the patients averaged longer in actual bed rest, pain demanded a longer interval for its control, vomiting, bleeding and abdominal pain persisted longer and blood improvement began later than when our patients were on our routine treatment. While Atkinson's statistics in some respects are more favorable than those I present, yet on analysis it will be seen that the general trend of his experience with mucin is in line with ours. Neither his nor my mucin data would seem to be an improvement upon those accumulated from ulcer patients subjected to the "physiologic rest" regime. The responses to the "acid test" of Palmer,[22] or to Hardy's[23] improvement upon it, similarly are confusingly variable. Certainly such responses would not appear to indicate that, if gastric mucin, administered per os, has the property of mechanically protecting injured visceral mucosae, such a characteristic has been exerted, while, though clinically comfortable, he retains positive Hardy phenomena.

Roentgen proof of the beneficial effects of mucin must be accepted only following careful scrutiny and comparison of films. From its inception, peptic "ulcer" is a *mural* lesion: the mucosal, ulcerative, localized defect is a complication of what, initially, was a non-ulcerative, mural focus of tissue damage. Even if one grants that gastric mucin, administered by mouth, mechanically protects ulcerated visceral linings, no one has shown that such surface protection influences favorably the mural defect. If roentgen films serve to visualize only ulcer craters, stenoses, localized or general abnormal muscular activity as a consequence of ulcer "irritation" arising at the mucosa, one must realize that though mucosal reepithelization occurs, much pathology still may remain in the visceral walls to remain capable of producing great disturbance in function. Indeed, the very *favorable effects of healing* of ulcer may result in scar which, roentgenographically, may be seen as added deformity, as stenosis, adhesion to neighborhood structures, delayed emptying-time or the hyperperistalsis associated with gastric contents having to negotiate stenoses. Hence, *greater* deformity, or peristaltic activity, may not be an *unfavorable* roentgen sign; often they are concomitants of healing. Absence of "niches" or of spasm must be interpreted carefully; not rarely, films vary much accordingly as exposures happen to be made with stomach, pylorus or duodenum in *systole or diastole*. Comparison of films exposed during each phase is needed to avoid erroneous conclusions. Following the hypodermatic administration of atropine (to the patient's individual point of tolerance, with a time interval sufficiently adequate) changes in contour, spasms, "stenosis" and visceral emptying rate must be judged comparatively. Rarely are the conditions which have been mentioned satisfied; hence, much confusion has re-

sulted from attempting to compare or contrast roentgen signs following ulcer therapy with mucin or other agents, signs which are in no wise of like foundation.

Atkinson states that in 18 patients the roentgen films of all showed improvement; the evidence of improvement he does not detail. In none of his 18 patients were unfavorable roentgenograms observed nor did any films represent conditions as they had been before the patients were treated by smooth diet and mucin. After employing the v. Leube-Sippy management, R. Brown reports no data concerning changes in roentgenograms. In our patients who received mucin, the films were what we considered favorable in 49 per cent, there were no changes in 39 per cent and in 15 per cent films revealed greater degrees of deformity, even though, clinically, the patients were comfortable. "Spontaneous healing" may account for marked changes in gastric contour; such often accompanies simple rest of the stomach as R. Brown demonstrated recently in an instance where the v. Leube-Sippy treatment had failed and he fed the patient by duodenal tube for a considerable period.

When our "physiologic rest" regime was employed, favorable roentgenographic films were available in 68 per cent, but in 18 per cent the films revealed greater than primary deformity as healing scar and its consequences had accumulated.

We feel that the evidences of improvement as revealed roentgenographically after mucin therapy by Fogelson and his group, and, certainly, in our own experience, do not warrant the drawing of supporting opinions.

Ulcer recrudescences following mucin therapy must be expected. We feel that not sufficient time has elapsed in our own group of patients to permit drawing worthwhile conclusions. It has been our custom to allow a two-year interval free of recrudescence before we feel that the mural lesion in the viscera is quiescent in a way which could be called "healed." Even then, we have had patients who had passed through years of short-interval recrudescences which seemingly, spontaneously stopped, have their affections again return dramatically as massive hemorrhage or perforative attacks, as long as five to thirteen years after the stormy, short-interval recrudescence phase. The status of affairs at the mural nidus, not at the mucosa, determines whether or not peptic ulcer will recur. Of 470 ulcer patients which we treated by our own regime, of those who had recrudescences, the symptom-and-sign-free intervals were increased from an average of nine and one-half months to thirty-two months. Fourteen per cent continued to have relapses. C. Brown's report that 37 patients treated by smooth diet and mucin had been "improved for one year" is encouraging.

Physical Well-being. Much has been said by Ivy for experimental animals, and Fogelson for patients, regarding the marked physical benefits and improved "nervous tone" of patients who were experiencing mucin therapy. Unfortunately, we have not observed these effects. However, we believe that when patients or experimental animals tolerate mucin well, physical benefits may follow. Mucin, as split in the jejunum, has rich potentialities as a concentrated food. The daily ingestion of 120 gm. of this glycoproteid serves as a strong "boost" to the limited ration given a dog which has been subjected to experimental surgery or a human to whom a milk, egg and cream diet is given. Potentially, if not actually, 120 gm. of mucin may mean an excess of 500 food calories. This "sugar protein," when cleavage has occurred, has a potential and doubtless actual nutritive value both from its "sugar" and its amino radicles. The latter are end-digestion products, quickly supplied and since they appear in the upper jejunum doubtless, within limits, are quickly absorbed.

In 1913,[24] clinically, I was able to show that by feeding directly into the duodenum such artificially prepared end-digestion

products as the amino acids, patients affected with grave degrees of malnutrition rapidly took on weight and experienced marked improvement in blood, strength and physical and mental well-being. In ulcer patients who are taking large quantities of mucin without difficulty and over long periods, the improved nutrition resulting therefrom might conduce to ulcer healing.

DISCUSSION AND SUMMARY

Peptic "ulcer," esophageal, gastric or duodenal in location, rarely begins as a *mucosal* lesion, even when appearing as the classic, acute, "punched-out," perforative type, graphically described by Cruveilhier. The primary visceral defect and the focus from which arise recrudescences, are a *mural* disturbance in tissue-architecture and specific, secretary function. *Mucosal* damage, which converts the *mural* lesion into one of *ulcer type*, is a complication or extension of *mural* damage demanding treatment, because then the *mural* lesion is limited in its capacity to repair by the proteolytic action of gastric juice. When the mural lesion has reached the stage in its pathologic history when it has assumed ulcer form, extension of mural damage continues until mucosal epithelization is reestablished; such epithelization may take place with restoration of normal secretary structures or without.

"Ulcer" healing, therefore, is resolved into two distinct and definite phases: (1) epithelial reconstruction, partial, without normal, histologic, glandular architecture or with such, and (2) the disappearance of the primary *mural* lesion. Unless the original *mural* damage is repaired by scar sufficiently adequate to replace the entire localized pathological condition the *mural* fault persists and hence the *mucosal* destruction, which consequently exposes the mural lesion to proteolysis, again may appear. In such circumstances, pathologically and clinically, it is stated that the peptic ulcer has "recurred."

There would seem to be many local, systemic or constitutional disharmonies capable of producing visceral *mural* pathology which may extend so as to include the *mucous* membrane and hence convert the *mural* lesion into one of ulcer-form.

It is evident that the therapeusis of peptic ulcer calls for *first*, the eradication of the *mural* lesion by excision or by measures which allow the development of scar tissue thus accomplishing the same purpose, and *second*, the attempt to restore mucosal epithelization, functionally differentiated or not. *Both* mucosal and mural healing are requisite for pathological and clinical cure: only by the healing of the mural lesion can recrudescences be avoided.

Non-surgical management of peptic ulcer appears to be followed by a form of healing, sometimes permanent, in from 60 to 77 per cent of instances. When management is directed toward placing the mural fault in conditions most favorable to functional rest, healing appears to occur more rapidly and to be more permanent (82 per cent) than where the management is directed chiefly toward *mucosal* restoration by measures (medicinal or otherwise) which so alter visceral contents as to prevent mucosal (and, secondarily, mural) proteolysis.

Fogelson's gastric mucin has been advanced as an agent which prevents mucosal proteolysis by "buffering" free HCl, by mechanically protecting injured mucous membrane and, perhaps, by improving systemic capacity for healing through the agency of increased nourishment. Proof seems to have been adduced by Ivy, Fauley, Kim and Whitlow that, in certain circumstances, gastric mucin prevents pathologic proteolysis of visceral tissue. Fogelson and others believe that, clinically, in humans, evidence is available which substantiates the work of those who have worked with experimental animals.

In a study of 39 patients affected with proved peptic ulcers, we have not been able fully to substantiate the claims of Fogelson, Atkinson or C. G. Brown or to demonstrate that mucin therapy adds factors of value when exhibited in connec-

tion with a suitable dietetic, hygienic and constitutional regimen, unless some worth may lie in a form of superalimentation by mucin as a food. As would be expected, since the *mural* lesion of ulcer, essentially, is not controlled by mucin therapy, recrudescenses are possible. In our experience, management by Fogelson's gastric mucin has proved unsatisfactory. Not only has it brought no specific clinical benefits not secured by other means, but treatment is handicapped because gastric mucin is difficult to secure and to preserve, is obnoxious as to odor and taste, is difficult to administer *as is* or with food, is "rule of thumb" as to dosage and effects, is expensive, leads to a false sense of security on the part of patients, and, in a group of patients observed by us, appeared to have certain toxic potentialities.

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THE STONELESS GALL BLADDER

A STUDY OF OPERATIVE CASES*

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EXPERIENCE has demonstrated that stoneless gall bladders are found in approximately one-third of all operations undertaken for the relief of symptoms diagnosed as of gall-bladder origin. As they are encountered at the operating table, these stoneless gall bladders present problems not found in gallstone cases. When stones are present, the surgeon can proceed at once with absolute confidence based on the stones themselves. On the other hand, the stoneless gall bladders more often than not present very little evidences of unquestionable gross pathology. If the surgeon is to proceed with confidence and good judgment in these cases, his decisions must be based on definite knowledge applicable to this particular class of cases.

Out of 433 operations on the gall bladder performed by me up to July 1, 1931 stones were absent in 113 cases. This series of 113 stoneless gall bladders will serve as the text for this discussion. The relatively low incidence of only 26 per cent of non-calculous cases in my series may be due simply to a statistical coincidence or it may be that it reflects the results of a certain degree of skepticism on my part concerning the necessity of surgery in many of these patients without stones. Generally speaking, it may be said that stones are absent in about one-third of all operations performed under the diagnosis of gall-bladder disease. A great majority of surgeons report a fairly constant ratio between the stone and the non-stone cases with from 30 to 35 per cent classified as cholecystitis without stones. Occasional enthusiasts have reported as high as 60 per cent of their gall-bladder operations on non-stone cases.

One of the first difficulties encountered in the study of the surgical aspects of the stoneless gall bladder is the necessity of eliminating cases operated upon under mistaken diagnoses. In the very nature of things, the group without gallstones must contain practically all of the gall bladders erroneously removed. If the preoperative selection of symptom-producing gall bladder disease is 90 per cent accurate, the non-stone group will probably contain close to 30 per cent of erroneous diagnoses which must be eliminated before accurate conclusions can be drawn from experiences based on these cases.

Until pathologists learn to recognize pathological changes which can be constantly associated with preoperative symptoms and postoperative end-results, we must I believe depend on the postoperative history as the only reliable means of confirming a causal relationship between the preoperative morbidity and the gall bladder.

Much of the literature on cholecystitis has been compiled from a viewpoint quite different from the strict end-result test method adopted for this study. An extreme example of this other viewpoint is seen in the article of Jones and Palmer.[1] Based largely on *x*-ray and pathological data, these authors claim 97.1 per cent correctness in their diagnoses and yet they report a postoperative continuance of preoperative symptoms in 78 per cent of their cholecystectomized patients.

Of the 113 stoneless gall bladder cases operated upon by me, 21 are found to have

[1] *Am. J. M. Sc.* October, 1930.

* Read at the 44th annual meeting of the American Association of Obstetricians, Gynecologists and Abdominal Surgeons, White Sulphur Springs, W. Va., Sept. 14–16, 1931.

been operated upon too recently for end-result determination, or were traced less than six months after operation. For the purposes of this paper, these cases will not receive further consideration. Two patients died following operation, one of acute cholangeitis, and the other patient, an acute case with perforation of the gall bladder, died of bile absorption and peritonitis.

This leaves, for end-result analysis, a group of 90 operated cases traced for a total period of 312.8 years, or an average of 3.5 years for each patient. If I were to apply the ordinary space basis method of tabulating my end-results, I could say that as these 90 patients existed (in space) at the time when their conditions were last known, 67 were in average health and quite free from any symptoms for which their gall bladders were operated upon. Thus, using the statistical method ordinarily used by surgeons in reporting their end-results, I could say that 67 out of 90, or 74.5 per cent, of my stoneless gall bladder patients made complete recoveries following their operations. The trouble with the space basis method of reporting end-results is that in an investigation of this kind even patients operated upon under gross errors of diagnosis, as for instance acute pericarditis, diaphragmatic pleurisy, or what not, may all appear as cured at the time of the investigation.

If the 67 ultimately cured patients are re-analyzed on a time basis, it is quite evident that 19 out of the 67 recoveries cannot be definitely credited to the operation. Some of them were in patients known to have been operated upon under mistaken diagnoses, as for instance, acute pericarditis or partial intestinal obstruction. In others, the symptoms continued for months or years after operation and finally subsided spontaneously or after treatment in no way directed to the biliary system. If we subtract these 19 cases from the 67, we have left 48 cases, or 53 per cent, of the traced patients definitely cured by the removal of the gall bladder, and 42 cases, or 47 per cent, in which the operation had no directly demonstrable effect on the morbidities complained of. Of these 42 patients not definitely relieved, the gall bladders were removed in 19 cases because adhesions between the gall bladder and the surrounding organs were thought to be of a pathologic nature and might very probably account for the abdominal disturbances complained of. It is worthy of note that in only one of the 19 cases is there recorded a history of acute abdominal pains diagnosed clinically as gall-bladder colic. This patient had had only one of these attacks in the course of a long history of somewhat ulcer-like indigestion. Severe financial worries may have been the cause of his indigestion. The removal of the gall bladder had no really demonstrable influence on the subsequent history of any of these 19 patients although several of them recovered from or at least changed their complaints months or years after their gall bladders were removed. Very probably, some surgeons would say that the removal of the rather hypothetical focus of infection in the gall bladder was responsible for the occasional ultimate recovery. This hypothesis is not subject to proof one way or another.

Four typical strawberry-type gall bladders were removed from patients suffering from supposed biliary types of indigestion with no demonstrable effect on their symptoms. None of the 4 gave a history of typical gall-bladder colic.

In 19 patients the subsequent history has definitely demonstrated that the gall bladder was not responsible for the symptoms complained of at the time of operation. In this group of known diagnostic errors, there are 7 heart cases, 2 of which were acute pericarditis, one, angina pectoris, one paroxysmal tachycardia, 2 myocarditis and one goiter heart. In view of the great frequency with which cardiac disease may somewhat simulate gall-bladder symptoms, and the fact that many true gallstone cases demand operation irrespective of co-existing heart trouble, it is interesting to

find in this series only one case of the angina type of heart disease. Operation in the one case of paroxysmal tachycardia was based on a misleading history, the diagnosis being perfectly clear with the next attack. The two heart cases which proved most confusing and embarrassing were 2 cases of acute pericarditis. I missed both of these diagnoses absolutely although both patients subsequently had typical attacks of acute pericarditis with effusion.

Two patients after operation were found to be suffering from hysteria and not gall-bladder disease. Until we develop some pathognomonic, hysteria-proof sign for gall-bladder disease, abdominal surgeons will probably continue to be fooled now and then by patients suffering from this condition. The woman with hysteria and a fair knowledge of the symptomatology of gall-bladder attacks is a dangerous diagnostic possibility.

One patient, uncured by her gall-bladder operation, subsequently developed cancer in the region of the head of the pancreas. The beginning but not-yet-recognizable cancer was probably responsible for the symptoms complained of previous to operation. Two patients had syphilis of the liver which was provisionally recognized at operation. Both were cured by anti-syphilitic treatment. Three patients were found to be suffering from partial intestinal obstruction in no way related to the gall bladder or the gall-bladder operation. The subsequent histories in 3 other cases showed that ulcers of the stomach or duodenum were responsible for their symptoms.

In the general literature on the subject, I have found no statistically usable data exactly comparable to the experiences just related. Some surgeons seem to have made no diagnostic errors. Others rely entirely on the minute pathological data. Some pathologists have reported series of gall bladders examined running into the thousands with less than 1 per cent of normal gall bladders removed at operation. Such apparent accuracy in the selection of gall bladders to be removed either places the data in the "believe it or not" category or proves quite conclusively that the minute microscopical findings of the pathologist may or may not be related to symptoms.

After having related in some detail the failures incident to pioneering in this unsolved field of surgery, it is with some satisfaction that we turn to a group of 48 patients definitely relieved of their symptoms by the operations performed on their gall bladders.

This group of 48 cured cases comprises 41 cholecystectomies, 6 cholecystostomies and one cholecystenterostomy, the latter performed in the presence of a common duct stricture. I was rather surprised to find 6 cholecystostomies in this group. I believe that cholecystectomy is the operation of choice in these stoneless cases and have performed no cholecystostomies in stoneless cases in recent years. However, to show that cholecystostomy may give brilliant results even in the presence of severe pathology, let me cite the following case:

Mrs. V., aged seventy-three, operated on July 29, 1913 gave a history of gall-bladder colics extending over a period of ten years, with a particularly severe attack three weeks before operation, that had made her an invalid up to the time of operation. Operation revealed an acute empyema of the gall bladder without stones. Notwithstanding the evident infection present and the greatly thickened walls, plastered over with omentum, a simple cholecystostomy was done. This woman had no recurrence of colic or symptoms referable to her gall bladder until the time of her death in November, 1927, at age eighty-seven, fourteen years after her operation.

This group of 48 cured cases is composed entirely of cases in which there is apparently a very definite one-to-one relationship between cause and effect, namely, the operation on the gall bladder and the cessation of symptoms for which the oper-

ation was performed. Nevertheless, a study of the gross and microscopic pathologic findings embraced in this group fails to show any constant pathologic findings. The descriptions of the gross pathology range all the way from "gall bladder apparently normal but removed because of the clinical history of gall-bladder colics" to "acute purulent cholecystitis." Likewise, as regards the microscopic findings, the laboratory reported at least 14 per cent of these gall bladders as histologically normal. Slight chronic cholecystitis was the usual microscopic finding. One very striking fact is that so-called strawberry gall bladders or cholesterosis were described only twice in the 48 cured-by-operation cases; whereas 4 of the 23 cases in the uncured-by-operation group were described as typical strawberry gall bladders. As cholesterosis is said to be demonstrable in over 30 per cent of miscellaneous autopsies performed on adults, it is questionable whether cholesterosis per se is a symptom-producing condition.

It is only when we turn to the clinical symptoms that we find what I believe is a real clue by which we can recognize before operation the cases destined to be post-operative successes and those destined to continue with complaints much like those described before their gall bladders were removed.

Forty-two of the 48 cured patients described attacks of abdominal pain which were so characteristic that when the histories were transposed to statistical cards, they were credited as having had definite gall-bladder colics. Of the 6 cases not so credited, 4 gave a history of painful abdominal attacks which probably should have been classified as typical gall-bladder colics. One patient complained only of dull pains in the right upper quadrant. In another case, the chief complaint was described simply as gas in the epigastric region.

Gall-bladder-like colics are described in only 8 histories of the 42 patients not definitely relieved by their operations and in 4 of these 8 cases, the subsequent histories and findings proved the supposed gall-bladder colics to have been due to other causes.

The foregoing observations, as to both the pathologic conditions and the symptomatology, are in accord with results reported from the Mayo Clinic. In regard to the symptomatology, Judd says of the non-calculous cases: "If the patient had had attacks of severe, colicky pain he was almost sure to obtain relief by cholecystectomy, but the results of operating for indefinite symptoms were very unsatisfactory." This relationship between true gall-bladder colics and good end-results is apparently very definitely shown in my series.

Some surgeons in reporting the end-results of mixed stone and non-stone series have stated that their patients were relieved not only of colics but of non-colicky digestive disturbances in almost equal proportions. This has not been my experience in either the calculous or the non-calculous cases. In the calculous cases, I have relieved the colics and the sudden gas attacks so common in this condition and probably produced by lesser grades of the same mechanism that produces the truly painful attacks. Also, I have relieved the complications such as are caused by duct obstructions and active infections. In the non-calculous cases, I have relieved those patients who presented clear-cut clinical pictures of biliary colic. In both the stone and the non-stone cases, I have very largely failed to relieve those less definite complexes of indigestion which I have, in recent years, come to look upon as due to causes not associated with the gall bladder. Stated in another way, I would say that in my experience my late end-results have borne a direct relationship to severity and classicalness of the gall-bladder colics suffered before operation. When I have attempted to cure by cholecystectomy indigestions which I hoped were of gall-bladder origin but which were not accompanied by quite recognizable attacks

of gall-bladder colic, I have almost uniformly failed to get satisfactory results.

The authors of a recent treatise on diseases of the gall bladder and bile ducts state that in their opinion there is no more interesting chapter in the history of medicine than the gradual development of the idea that this organ is accountable for much of the dyspepsia, much of the partial invalidism and even a fair proportion of the cancer of the world. They also state: "This is in striking contrast to the older view which regarded as cases of chronic cholecystitis only those in which there were recurrent attacks of biliary colic."

This so-called newer concept of the morbidities due to cholecystitis may be correct but I doubt it. If the gall bladder were really responsible for the symptoms ascribed to cholecystitis without biliary colic, the removal of the gall bladder should promptly and permanently do away with the symptoms. In my experience this has not been the case unless biliary colics were the dominating feature of the clinical picture.

In conclusion, let me emphasize the following points:

1. All actual objective data that I have studied points to the conclusion that in the present state of our knowledge the one reliable indication of gall-bladder disease of a type yielding to surgical intervention is the presence of well-defined attacks of gall-bladder colic. If the surgeon is definitely certain of his ground relative to the clinical history of biliary colic, he can proceed to remove the gall bladder irrespective of obvious pathology recognizable at the operating table.

2. Just so far as the clinical picture of true biliary colics becomes doubtful, or the clinical picture shades over into ill-defined digestive disturbances of the general type that many surgeons have been wont to call the symptoms of the precalculous stage of cholecystitis, do the end-results of operative treatment begin to fail.

3. It seems highly probable that the indications for operation must be based and justified almost wholly on the symptomatology, and that little reliance can be placed on the pathologist's report until such time as pathologists learn to recognize a pathologic condition corresponding to the symptomatology.

TOTAL PERINEAL PROSTATECTOMY FOR THE SMALL PROSTATE*

A SECOND REPORT

E. GRANVILLE CRABTREE, M.D.

BOSTON

ON a former occasion I presented before this Society what I preferred to call an experimental group of small prostatic gland cases treated by radical prostatic surgery. For want of a better term I referred to these small glands in contrast to enlarged benign hypertrophics as fibrosis of the prostate —fibrous prostates.

Dr. Morrissey expressed what he felt to be his need of definition—and which still remains an important weakness in terminology for us all—when he asked me in discussion what I meant by the term fibrous prostate. My answer indicated that I had used the term to refer to those small glands in which the fibrous and muscular elements of their composition predominated and in which the glandular hyperplasia was either absent or limited in amount. Perhaps limited glandular hyperplasia should be considered the result of fibrosis because the enlarging glandular elements are limited in growth by the surrounding masses of fibrous tissue. There seems to be general agreement concerning the nature of the adenomatous hypertrophy type of gland. Few of us will disagree with the most excellent demonstration in Randall's recent book on pathology of the prostate. However, there seems to be many widely divergent opinions held, if surgical measures employed for relief are evidence, concerning the obstructing mechanism present in the small glands. One occasionally sees, in almost any clinic, operators either by the perineal route or suprapubically attempting to enucleate adenomatous tissue from a type of gland which when seen at autopsy or in specimens removed by the radical operation show little if any enucleable adenomata. The results of such surgery are not satisfactory to the urologist as a rule. Urology should be capable of producing surgically sound operative procedures applicable to the small glands and capable of producing results comparable with those for the benign hypertrophies.

Without doubt the present enthusiasm for punch operations had its beginning in attempts to relieve obstruction in these atrophic fibrous glands. They mean prostatic bar alone to many of us now. Yet we are all conscious of considerable variations in these glands. Occasionally one sees a prostate of atrophic nature associated with undeniable evidence of obstruction to the urinary flow which when removed in its entirety weighs but 4 or 5 gm. This gland has clearly caused total obstruction. There is undeniably either the glandular or fibrous bar type of obstruction associated with the small type of gland where the prostatic urethra appears cystoscopically to be freely open, and a urethrogram shows it to be so. On this type of case I do a cautery punch operation with the conviction that I am discharging my obligation to that patient both for the present and the future. There is a third type of small gland, which group I now believe to constitute a considerable portion of the whole where, even though the gland is composed chiefly of fibrous material, attempts at adenomatous hyperplasia has occurred in some portion of the gland. Small lateral lobes are held firmly approximated in the inelastic fibrous tissue

* Read at the meeting of the New York Society of the American Urological Association, October 28, 1931.

in such a way as to offer obstruction even after some relaxation of the gland is obtained by cautery treatment of the prostatic bar. In the most pronounced of these cases enucleation operation leaves behind much deformed prostatic tissue, often harboring infection, and yields the smallest of adenomatous specimens. Often the result functionally is excellent. In other instances the patient either remains functionally embarrassed or contracture from scar tissue requires long periods of dilatation. Adenomatous tissue occurs in such glands in any of the usual places such as lateral lobe, commissural lobes, subtrigonal nodules or miniature general hyperplasia.

It is as yet too early to determine what the fate of this latter type of gland will be in later life after treatment by median bar cautery alone. Already it seems to be true that infection remains a troublesome factor in some although the bladder has been enabled to function passably well after median bar relief. Carcinomatous degeneration is equally probable in the punched and the unoperated cases. The next ten years will show interesting end results from this surgery. Partial prostatectomy in the adenomatous hypertrophy as practiced a generation ago was abandoned as inadequate.

Meanwhile, I again offer for your consideration total removal of these glands except where prostatic bar alone exists. This I believe demands only section, and cautery punch is the preferred means for accomplishing it.

Since my first cases were presented, I have operated on a few cases by total prostatectomy, primarily for obstruction, but secondarily for extensive and long-standing prostatic gland sepsis. The operation has a definite application to this type of case. Hinman has recently reported 5 cases so treated.

I have already described the technique employed in performing total prostatectomy on the small gland, but will review it later. Essentially it is that employed by Young for total prostatectomy for cancer. When one operates for the small gland in contrast to the cancerous prostate, it offers no technical difficulties. In fact, I find that for me total prostatectomy for the small gland is less difficult technically than attempts at partial removal either by enucleation or dissection by either the suprapubic or perineal route.

To date I have performed this operation on 26 cases with a mortality of one. The patient who died had large bilateral diverticula and extensive renal damage. Death was due to bronchopneumonia on the ninth day after the prostatectomy. Diverticulectomy had been performed some weeks previous to the prostatectomy.

All living patients have been followed to date. Ultimate satisfactory results were obtained in all but one. This patient has continued to have leakage on exertion, coughing, or sudden motion. Even though sepsis was present previous to operation, the urine has cleared entirely. He voids in normal amounts.

One patient out of the 25 now living has already been reported in my previous communication as having had temporarily some degree of loss of control but recovered after four months. He is now entirely in control of his micturition.

One patient who showed much sepsis remained irritable for about a year. After the passage of sounds this symptom disappeared.

In a survey of postoperative results in prostatectomy cases which I have made during the past year both from the clinical aspects of restoration of satisfactory function and cystoscopic findings and by urethrography, total prostatectomy cases showed the most satisfactory results of all the types of operation which had been employed. From the clinical, cystoscopic and *x*-ray point of view, total prostatectomy gave us our best final results. Since some of our cases were operated upon several years ago, these results can reasonably be expected to represent final results.

CASES OPERATED ON	DATE
2	1924
3	1925
3	1926
1	1927
4	1928
3	1929
3	1930
7	1931
26	

The number of cases to which total prostatectomy is applicable will probably be but a small part of all the cases of prostatism. I know of but few statistics indicating the relative frequency of occurrence of the small gland. Randall's figures from autopsy cases are probably the fairest estimate of the relative frequency of hypertrophy to small gland types. While he chose to classify his cases into "gross pathological changes" and "median bar cases" perusal of his pages and reference to his photographs indicates that by "gross pathological changes" he referred to the large hypertrophied glands. All other types of obstruction except carcinoma, tuberculosis and abscess, he seems to have included in the second group. His figures are as follows: of 312 cases showing prostatism, 222 were due to "gross pathological changes," while in only 57 cases was the small type gland encountered. There seems to me to be great need for subdivision of this small group along the lines which I suggested earlier in this paper. By such subdivision suitable cases for punch and cautery procedures will be established as well as a group in which total prostatectomy will find its place as a useful addition to our armamentarium of surgical operations.

DISCUSSION

Dr. Edward L. Keyes: The Crabtree operation is not a suitable method, in my opinion, for attacking prostatic bars in young or middle aged men, since it almost invariably destroys the sexual function. But it does seem quite appropriate in the treatment of the truly sclerotic prostate, the type whose very existence Randall has denied. One of my patients died some years after an operation performed on him by me which had left him with about 100 to 150 c.c. of residual urine. Autopsy showed the bladder neck (where the bar had been bitten away) wide open, as at the time of operation, but the whole posterior urethra was just as sclerotic as ever, and perfectly rigid. I believe the retention of urine was due to the rigidity of the prostate. It is a practical illustration of what Dr. Crabtree means in stating that some patients will not be relieved by operation other than total prostatectomy. However, I confess such cases are less frequent in my experience than they seem to be in his.

I am at present engaged in reviewing this type of case, and have been interested to find that some of the cases have gone a great number of years quite satisfactorily after various operations attacking different types of prostates ranging from the simple bar to the totally sclerotic type due to prostatic abscess or other inflammation of the gland sufficient to render it rigid throughout.

I have operated upon cases by other forms of operation than Dr. Crabtree's and found they required a great deal of after-treatment. And I think some of his will require a fair amount. For after all, some scar tissue is left and even at times a crookedness of the urethra. In fact, he mentions a case done a year or so ago which shows some tortuosity of the posterior urethra needing to be ironed out.

Dr. Nathaniel P. Rathbun: When Dr. Crabtree made his first presentation here two years ago, I confess I was not at all enthusiastic about this operation. It seemed to me a logical procedure, but too radical. It appeared that in the hands of the average operator, it might have unfortunate sequelae, such as incontinence, that it would be difficult to do the operation without damaging the sphincters or causing enervation. Having seen Dr. Crabtree perform this operation, and having done it myself, and hearing again his further report on its satisfactory results, I have reversed my position. I am very enthusiastic about the Crabtree operation. I feel that he has made a major contribution to urology in his modification of Young's operation.

My experience in handling these cases in the past has not been satisfying. I have

had very few altogether good results. I have treated them in various ways, by punch, suprapubic prostatectomy, going in with the finger and fingernail and gouges to chew out pieces of tissue amounting in the aggregate to the size of a normal prostate, etc., altogether unsurgical procedures, I have felt. Residual urine has been reduced, but frequency has continued in many instances almost as bad as before operation.

I agree with Dr. Keyes (in fact, Dr. Crabtree says himself) that these cases for his procedure will have to be carefully selected. It seems to me that a year or two ago, before I was convinced of the value of Dr. Crabtree's operation, I saw many more opportunities to test it out, and that since I know its merits I have seen very few, in fact, the total number of cases coming to surgery of late has been decidedly less. I have performed this operation only once or twice lately. I was, however, impressed with the ease and facility with which it can be done. I do not claim to be an expert in surgery of the perineum. I have felt that the Young prostatectomy offered difficulties in my hands; and yet with my limited experience I felt at ease with Dr. Crabtree's procedure. It is, in my opinion, simpler than the ordinary form of Young prostatectomy. Dr. Crabtree has illustrated to us the way the bladder neck is peeled back; and the ease and facility of completing the anastomosis of the open ends is striking. Also, it is easy to get the feeling of a smooth, tight sphincter after removing the prostate.

I believe this operation may even be extended a bit. I have in mind another group with unsatisfactory results, the cases of prostatic calculi. Such cases as I have seen have always been associated with fibrosis of the prostate, many of an obstructive nature. They offer a trying experience at all ages. I have gone in from above and taken out pieces of prostate, and removed gravel and stones. And on sending the patient down for a roentgenogram before leaving the hospital I have been surprised to find that there were still calculi at the bladder neck. One of the cases in which I employed Dr. Crabtree's operation was in this group. Both the calculi and the prostate were removed, and there was an absolutely perfect recovery. There was no residual urine, the patient passed a good stream under perfect control, and slept all night.

Another group of cases in which, as one becomes more expert, this operation may be useful is the early type of carcinoma of the prostate, calling for operation of a radical nature. Most of the cases that I see in which the diagnosis is a certainty are beyond my skill for radical operation. Occasionally, however, we see cases in which early carcinoma is suspected but in which we cannot definitely make a diagnosis. A few years ago we hesitated to recommend a radical prostatectomy on such patients because we were afraid of incontinence following operation. I feel perfectly at ease on that point now and shall not hesitate to recommend and perform a total prostatectomy on just that type of case, feeling that I may effect a radical cure in an early case, or if I am mistaken in my diagnosis, that I have done the patient no harm.

Dr. Oswald S. Lowsley: I think that for one as proficient in this operation as Dr. Crabtree is, to have operated upon only 7 cases by this method in the past year also earns him the title of being the most modest pioneer I have ever met. It might prove an example to some of our other pioneers.

No discussion of prostatic surgery can omit the various punch operations, the Young operation, and such procedures, of course. I am sure these will all be tried on the type of prostate Dr. Crabtree has selected for his operation, and quite agree with him they will often not prove suitable procedures. For the fibrosed prostate such as he has described, total prostatectomy seems exactly the thing to do. Yet the cases which can be so treated are very limited indeed. Since hearing his paper two years ago I have been stimulated to try the operation, and have performed it twice. I have been searching very assiduously for cases in which I felt justified in doing it. I will admit, also, that one of these prostates was totally removed because I thought it an early case of carcinoma; and I still believe it to be such, in spite of negative reports on specimens. The patient is apparently well now, yet I feel the condition is a malignant one.

The question of technique taken up in Dr. Young's recent article is an important one. That is, it emphasizes the value of preserving the network of blood vessels on top of the prostate, and leaving a foundation layer of fibrous tissue and part of the capsule, if necessary. Otherwise there is a lot of bleeding

and injury to the nerves, which is of importance in connection with continence afterwards. If we destroy this entire tissue, incontinence is much more likely to follow.

Dr. A. R. Stevens: It seems to me that Dr. Crabtree has been very careful to confine this type of prostatectomy to a very small group of cases. The fact that he has been interested in the operation over a period of seven years and yet up to 1931 has found no more than 4 suitable cases in any one year, indicates a belief that there is only a comparatively small proportion of prostatics which should be handled in this way. That group may properly include certain cases of fibrosis which come after an obviously acute infection. But the group he has in mind, and in all probability the one we will encounter most often, is that of fibrosis in its comparatively broader meaning—i.e., with no history of acute infection of the prostate.

My difficulty has been to differentiate between the cases of prostatic obstruction, not due to carcinoma or hypertrophy, which will be helped by the punch operation and those which will require total removal of the prostate. I have operated in this way only twice, with this in mind: that the smaller operation should be tried first and prostatectomy employed on individuals who had had punch operations without relief. One case was an individual who had foul residual urine and multiple small diverticuli of the bladder (part of which contained calculi). On his first admission these calculi were removed, and a punch operation performed under suprapubic control. He was more comfortable following this, but still had frequency and foul urine, with more or less residual. He returned eight months later with increased frequency, purulent urine, one calculus in a diverticulum; and it seemed wise to operate to remove this calculus. Again a piece of the prostate was removed by punch operation. He healed after this, but still had about 2 ounces of residual urine and very marked frequency by day and night. We were at a loss to know what to do. A great many bladder irrigations were given, without relief. It occurred to me that by taking out the whole prostate according to Dr. Crabtree's method and getting rid of the residual urine, the formation of calculi would be less likely to take place, and at the same time the patient would be given a better opportunity to overcome infection. The result was that he was relieved of his residual urine, made an excellent recovery, had perfect urinary control; but when last heard from, about four months after leaving the hospital, he was still very uncomfortable and had marked frequency of urination, obviously due to the infection.

In one other case where the prostate was completely removed (a man fifty-two years of age with a history of twelve years of urinary frequency), within twenty-four hours after he entered the hospital and before we had had an opportunity to examine him thoroughly, he had a very marked discharge of pus from the urethra, quite apparently coming from a ruptured prostatic abscess. He was under treatment with hot rectal irrigations and the usual therapy indicated in such conditions for many weeks. He finally developed considerable fever, which was regarded as caused by infection of the prostate and bladder. A suprapubic opening was made. The fever came down, and afterwards we did a punch operation. He healed, but still had 10 ounces of residual urine. We therefore removed the prostate according to Dr. Crabtree's method; and while the first case mentioned offered no difficulties, this one was a more or less complicated one, inasmuch as he had a great deal of periprostatitis. He finally healed without too much difficulty, was relieved of his residual urine, had control when lying down, but on walking around there was occasional slight leakage.

Dr. J. Sturdivant Read: I agree that this procedure of Dr. Crabtree's is a distinct contribution to prostatic surgery. The selection of cases in which it is indicated has been discussed by the previous speakers, so that I will consider it from another angle.

First: Surgically, is it easily done in the average competent hands?

Second: Is there any particular shock to the old or feeble patient?

Third: Is it more apt than any other perineal procedure to be followed by permanent leakage of urine from either a perineal wound or from the meatus?

I can only give you the results of 4 cases done by myself; and as I am not very familiar with perineal surgery (most of my cases for years have been done suprapubically), I think that my conclusions are a fair answer to the foregoing questions.

Case I. That of a feeble old man of seventy-three years, admitted in retention. Suprapubic drainage was necessary for thirty-eight days before the patient's general condition would allow of further surgery. We followed Dr. Crabtree's procedure. The usual curved incision was made, the urethra cut across, and the prostate delivered and resected. I was surprised by the amount of slack between the cut urethra and the bladder. It was easy with an ordinary needle holder and curved needle (no boomerang or gadgets) to place three chromic sutures approximating the bladder neck and the cut urethra. As this was my first case, I wondered if the approximation would hold, and feared a permanent fistula. The patient made an uneventful recovery in three weeks. After five months I find that he urinates without difficulty, has no residual urine, and has complete control. Forty minutes before operation, 2 c.c. of 0.5 per cent nupercain were given. Anesthesia was complete during operation and for two hours postoperative.

Cysto-urethrogram taken while voiding (Fig. 1) shows good approximation and normal appearance of the prostatic urethra after prostatectomy. The narrowed portion of the urethra between the bulb and the prostatic part is due to the action of the compressor urethrae muscle.

Fig. 1.

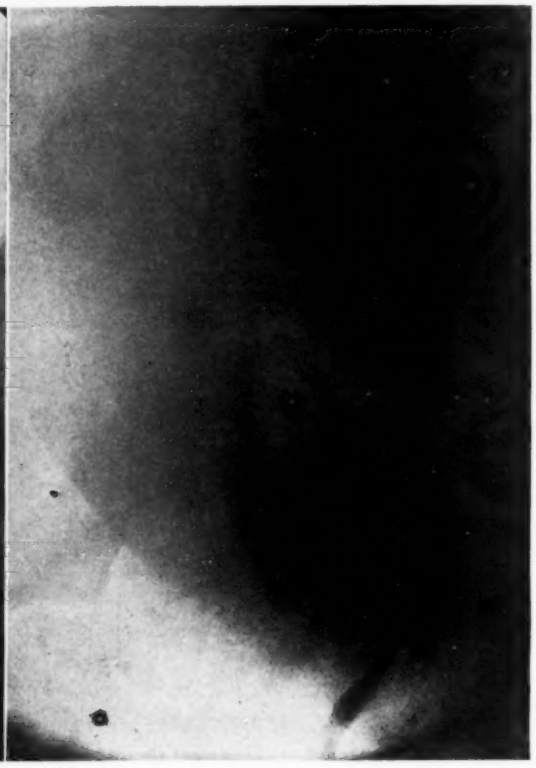

Fig. 2.

Case II. Man sixty years old, with a small fibrous prostate. The patient was operated on in the same manner. In this case, hemorrhage necessitated packing in one corner. Consequently there was considerable infection. The night of operation, the patient pulled the urethral catheter out, and leakage of urine through the wound added to the infection. Two and one-half weeks afterwards the exposed urethra could be seen with urine trickling through. An urethral catheter was inserted, worn comfortably for two and one-half weeks, the skin flaps sutured, and complete healing took place. The result four months later was reported as disappearance of the 8 ounces of residual urine, no perineal fistula, and complete control. The pathological report was prostatic adenoma with focal malignant areas.

Cysto-urethrogram taken while voiding (faint outline because patient moved) shows smooth junction of bladder and urethra. (Fig 2.)

Case III. Adenocarcinoma of the prostate and vesicles. Symptoms of mild prostatism for four years, severe for three months. In retention for three days. Suprapubic drainage under spinal anesthesia, for ten days. Prostate was fixed, one lobe projecting into the bladder along the posterior surface of the internal sphincter. Bladder membrane healthy. Using Young' retractor, this prostatectomy proceeded smoothly. The vesicles were cut across at a convenient point, along with the urethra. A No. 20 Fr. urethral catheter was put in place. There was complete closure in seventeen days, and the patient was home in thirty days.

Clinic note five months later: Function perfect. Urinates every three hours. Cysto-urethrogram taken while voiding (Fig. 3) shows smooth junction of urethra and bladder, the ureter narrowed near the bulb, due probably to contraction of the compressor urethrae. The bladder is elongated, due probably to fixation in the surrounding tissues.

Case IV. Man sixty-six years old. Symptoms of prostatism for four years, frequency every two hours, and residual of 2 ounces. Prostate per rectum small; adenoma. Two c.c. of 0.5 per cent nupercain produced a 60 per cent successful anesthesia. The membrane in the bulbous urethra was extremely thin. The urethra was approximated to the bladder with three chromic sutures, which were tied loosely for fear of cutting through. Nevertheless, because of the large amount of slack there was firm union. There was a slight perineal fistula for thirty days, but four months later the clinic report is "no residual; frequency every four hours; control perfect."

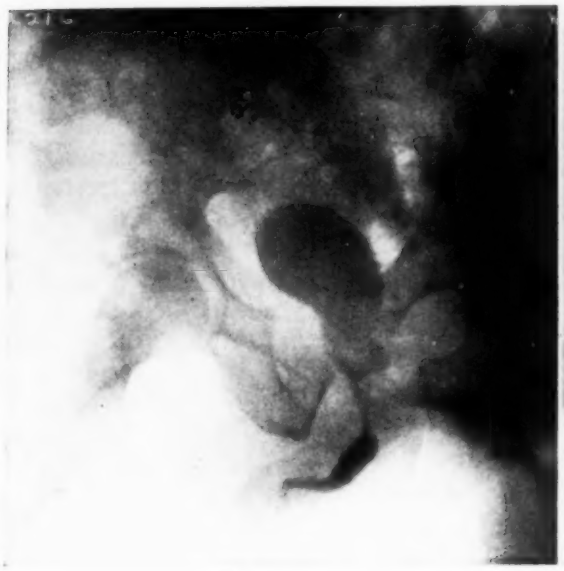

Fig. 3.

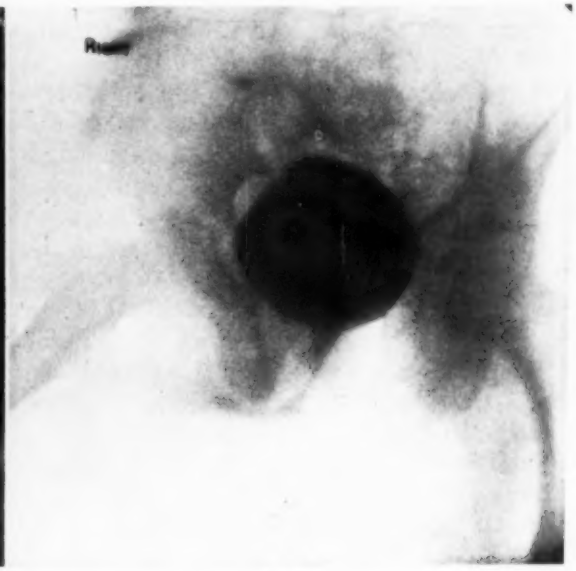

Fig. 4.

Cysto-urethrogram in semilateral position taken while voiding (Fig. 4) shows smooth junction of the urethra and bladder, and the usual narrowed membranous urethra, which is interpreted as action of the compressor urethrae muscle.

The question of when to use this operation is open to judgment. But I know that it is a simple procedure, that function in my 4 cases is perfect, and that there is no residual urine in any of these cases.

Dr. Edwin Beer: Of course the whole question resolves itself into just what cases are to be treated by Dr. Crabtree's operation. He has not outlined how to recognize them preoperatively. It seems to me rather difficult to determine without opening the patient up. In a case with fibrosis of the prostate and contracture of the neck of the bladder, one often detects, after wide incision into the fibrous prostate, a narrowing of the urethra beyond the reach of the finger. Such cases are those which Dr. Keyes has mentioned. Under these conditions, a total prostatectomy seems indicated; but how to recognize it preoperatively, I at present fail to see. When the bladder is once opened and we have such

a finding, we can take out practically all of the fibrosis from above with the electro-cutting needle, down to the compressor muscle.

I would like to know what Dr. Crabtree has found in cases coming to autopsy some months after the operation. Judging from Dr. Read's pictures, I should say that the bladder retracts from the compressor muscle region and a new posterior urethra forms. I do not believe that in these pictures the neck of the bladder was near the compressor muscle. I noticed in the course of the discussion that some of the gentlemen seemed to be under the impression that the sphincter at the neck of the bladder controls bladder function. I am very definitely of the opinion that after prostatectomy the internal sphincter fails to function in the great majority of cases, and that urinary continence is entirely due to the compressor muscle. Many studies of the posterior urethra after prostatectomy, both by urethroscopy and injection, have shown in innumerable cases that the internal sphincter function was borne by the compressor muscle, this muscle alone supporting the column of water in the bladder.

Dr. Howard S. Jeck: In line with what Dr. Beer has just said, I should like to know if Dr. Crabtree found any temporary incontinence after any of his operations.

Dr. E. Granville Crabtree (*Closing*): In answering the queries of various members, I confess I do not know to just what group of cases this operation will eventually be applied. Experience will have to determine that. As Dr. Lowsley has commented, I do not believe I have been over-enthusiastic in operating on 26 cases over a period of seven years. My enthusiasm has been tempered by the one point emphasized so many times here, namely, that there is difficulty in making an accurate diagnosis of the size and condition of the prostate. I have felt that certainty of diagnosis was not always possible by cystoscopy, by rectal examination and the other usual means, and have therefore attempted to employ urethrograms for that purpose. I shall later publish my experiences with urethrography, so that you may judge how far I have gotten with this method.

My impression is that you here have extended the application of an operation which I had confined to the small type of gland essentially fibrotic in type. You have reported its use in doubtful cases of carcinoma. I believe such cases belong to this group. Some of them were actual cases of carcinoma, some believed to be and found benign. Dr. Read has reported an ordinary-sized adenomatous prostate operated by this method. Dr. Hinman, in his last publication dealing with prostatics, reported 5 similar cases with infection, and showed pathological specimens of quite large benign hypertrophies operated in this way. Dr. Keyes has suggested still another type of gland to which it is applicable, one to which I have perhaps referred but not been definite about.

I feel that time alone will give us definite knowledge of just what group of cases will be suitable for this operation. I am absolutely convinced that the number will be small. Total perineal prostatectomy will not revolutionize prostatic surgery.

Several speakers have reported residual urine after the operation of prostatectomy. I would call your attention to the fact that in neither my cases nor those mentioned by other operators here has residual urine been reported, although tested for in all cases.

As to autopsy findings, there has been but one performed, and that nine days postoperatively. All other patients are living.

Dr. Jeck has mentioned postoperative incontinence. One patient previously reported completely recovered normal control, and has continued in this condition for two and one-half years, though for four months postoperatively he had slight incontinence, that is, a few drops on exertion.

RECURRENT BENIGN PROSTATIC HYPERTROPHY*

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THE operation of total prostatectomy has always carried with it the thought of a complete cure and the absence of recurrence. Since Freyer demonstrated his operation (prostatectomy) in 1901, the procedure, with slight modifications, has been carried out in thousands of cases. Most doctors and all patients had believed or had been told that the procedure was an absolute guarantee against further similar trouble. However, at this time we are gradually beginning to change our conception and realize that recurrent prostatic adenomas are more common than we had supposed and may even produce complete urinary obstruction again and develop to a size even larger than at the time of the first enucleation.[1-4]

The adenomatous prostate tends to hypertrophy with age and increases constantly in size. In occasional cases this growth is rapid but is usually slow and may even have remissions. There is no tendency to necrosis, ulceration or metastasis. The growth is painless and the symptoms produced are due to pressure, except when hemorrhage occurs. Adrion[5] and Loeschke[6] showed that the prostate consists of three types of glands: mucosal, submucosal and prostatic. Motz[7] and Perearneau[8] wrote that all hypertrophy of the prostate arises from the mucosal or submucosal glands. Tandler and Zuckerkandl[9] and others have confirmed this work. The enlargement always begins in the inner or mucosal glands and is always central while the hypertrophic processes very seldom begin in the prostatic glands proper, or outer glands. However, the latter may occur and occasionally one sees an isolated spheroid of hypertrophy there. This undoubtedly accounts for certain cases of recurrence after complete prostatectomy (Young[10]). As the hypertrophic masses grow the unaffected prostate becomes fibrotic.

The cause of recurrence of benign prostatic hypertrophy seems to be a disputed subject. Takahashi[11] advanced the idea that the prostatic capsule is not a true capsule but a tissue composed of flattened glands which take on an activity of regeneration of the gland structure when the pressure has been removed by prostatectomy. Hedinger[12] substantiated this view by finding distinct recurrence of glandular tissue in autopsy specimens two and four months after prostatectomy. Tandler and Zuckerkandl, Honegger[13] and Blum[14] also support this theory. Freudenberg,[15] first an advocate of this theory, later came to believe that the regeneration did not take place from the glandular tissue of the so-called capsule, but from small adenomatous nodules left at the time of the first operation. Jacoby[16] studied the glands of the prostatic urethra and differentiated them into mucous, submucous and prostatic. The submucous glands form the cervical group about the vesical neck and may give rise to the pathological middle lobe and are also located on the anterior or ventral wall of the urethra. These urethral prostatic glands are the sites of the hypertrophic centers and are continuous with the prostatic glands in the prostatic capsule. He believes these centers become more active after prostatectomy and permit expansion to the point of producing obstruction.

The literature to date contains only about 40 cases: Andre one, Bazy one,[17] Constantinescu one,[18] Fedoroff one, Hedinger 2, von Illyes 4,[19] Loumeau 2,[20] Lumpert one,[21] Takahashi one, Zuckerkandl one,

* Submitted for publication December 14, 1931.

von Grigoracis 3, Pauchet 5, Frank one, Nogues one, von Krois 2,[22] Honegger one, Gregora 3,[23] Young 3,[10] Lewis one,[24] Cunningham 3,[25] Le Fur 2,[26] Freudenberg 3.

Grigoracis reported 1 per cent in 300 cases of suprapubic prostatectomy in the clinic of Rafin, and Illyes 3 in 470 cases. Bazy[17] and others comment that the perineal route is not so favorable for exploration for remaining glandular tissue or nodules as the suprapubic and therefore is more likely to be followed by recurrence.

Most of the patients reported are over sixty years old, though there have been a few below this age level. Some patients have no symptoms of regrowth but reveal such on rectal or cystoscopic examination. It has also been suggested that most prostatics die before a sufficient time has elapsed since the first operation to permit regrowth. The recurrence usually produces symptoms after eight to ten years, and are similar to those in the unoperated group. The examination may reveal lateral or median lobes, though the former are more common and in many cases even larger than at the time of the first operation. There is usually no fibrosis about the adenomatous nodules, so that the enucleation is no more difficult than at the first operation.

My patients were sixty-two and sixty-one years old respectively.

Case 1. S. M. sixty-two years of age, had been operated upon by a competent surgeon in November, 1926. A two-stage complete prostatectomy was performed at that time. The tissue was reported a pure adenoma. In September, 1930, he developed gross hematuria and later urinary retention, necessitating catheterization. Examination at that time revealed a large recurrent adenomatous hypertrophy of the prostate, the size of a small lemon (2 × 1½ in.). Palliative treatment was instituted and the patient was well for about one year. In September, 1931, the same symptoms recurred, but the prostate had become much larger. Residual urine totaled 4 fluid ounces. Cystoscopy revealed a moderately trabeculated bladder with marked intravesically and intraurethrally intruding lateral lobes. Vocal cord action could be demonstrated. An operation was decided upon. A suprapubic two-stage prostatectomy was performed and an adenomatous prostate, the size of a small orange (3 × 2½ in.) was easily enucleated. No abnormal amount of fibrosis was noted. The patient made an uneventful recovery and left the hospital in five weeks, voiding per urethram. Pathological report: cystic adenomatous prostate.

Case 11. H. L., sixty-one years old, had a complete prostatectomy in September, 1929, by a competent urologist. The pathologist reported adenoma. In August, 1931, the patient consulted me, complaining of urinary frequency. Rectal examination revealed an adenomatous regrowth, the size of a walnut (1½ × 1 in.) and residual urine of two fluid ounces. Cystoscopy revealed a moderate intravesical intrusion of the lateral lobes. The patient was treated conservatively and improved symptomatically. At the present time no operation is necessary, but if the adenoma continues to grow, a complete enucleation may become necessary.

CONCLUSIONS

1. Prostatic adenomas do recur and may produce symptoms as severe as at the time of the first operation.

2. Recurrence may be due to nodules left at the time of the first operation or activity in regenerative centers in the prostatic capsule.

3. At the time of the first operation one must be extremely careful to remove the entire adenomatous prostate with nodules, etc.

4. Two cases are reported: one had recurrent symptoms with obstruction within four years and had a second prostatectomy after five years. The second has symptoms with palpable enlarged recurrent adenoma within two years.

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[For Remainder of References see p. 269.]

PROBABLE BILATERAL TUMOR OF THE CAROTID BODY

REPORT OF CASE*

GEORGE DE TARNOWSKY, M.D.

CHICAGO

NOT only are carotid body tumors of rare occurrence (143 cases up to the year 1930 were reviewed by Bevan and McCarthy) but, including ours, only thirty-two tumors of this type have been removed without ligation of any blood vessels. Still more rare are the reports of bilateral tumors of the carotid gland, in which our report belongs, although the hospital records of the first operation are not available.

CASE 1. Cook County Hospital No. 1187130. A forty-four year old Italian workman, giving a fictitious name on admission, entered the hospital September 12, 1930 for treatment of a swelling in the right side of the neck which had been present for twenty-six years.

Previous History: Twenty-six years ago (1904), he stated that a similar tumor had been removed from the left side of the neck by the late Dr. Camillo Volini, at the German Hospital (now Grant), Chicago. The tumor, according to the patient's statement, was solid; the incision was made at the apex of the left sub-maxillary triangle, the growth removed and wound closed without drainage. No recurrence of the tumor occurred. During his stay in the hospital it was noted that the right side of the neck had begun to exhibit similar swelling. The patient left the hospital without further surgical intervention but returned later (1906), when he was treated by a Dr. Senn for syphilis.

Present History: The tumor has remained stationary as to size and location and is painless unless pressure is applied against it.

Examination: A well-nourished white male of forty-four years of age, not acutely ill. Temperature 98.6; Pulse 78; Respirations 18.

Head, negative.

Neck: No adenopathy; on the right side of the neck, in the submaxillary region, is a tense, smooth, fluctuating tumor about 1½ inches in diameter, movable laterally and not tender. A distinct impulse can be felt which gives one the impression of being expansile in nature but which may be transmitted impulse from the carotid arteries. No bruit is heard, but the heart tones are audible over the tumor. There is an old scar in the left submaxillary region.

Chest: Lungs and heart negative. Abdomen: negative. Genitalia, extremities, reflexes, normal. Wassermann-Kahn reactions, negative.

Working Diagnosis: (1) Branchial cyst. (2) Cyst of submaxillary gland. (3) Thyroglossal cyst. (4) Aneurysm of carotid artery.

Diagnostic review, September 16. Above findings noted and confirmed. There is a small-egg sized painless nodule on the anterior surface of the right sternomastoid. Impression: (1) Lymph gland, either tubercular or metastatic carcinoma; (2) bronchial cyst; (3) small hygroma.

In retrospect it seems strange that the true nature of the growth was not even suspected because, in the September, 1916 number of *International Abstract of Surgery* the writer had presented a rather exhaustive differential diagnosis of congenital malformations of the neck, making the statement that "a solid tumor of long standing, situated in the anterior triangle of the neck, at or near the level of the lower border of the thyroid cartilage, should be looked upon as a possible carotid body tumor and removed before it involves the surrounding tissues, particularly the carotid sheath."

Operation, September 17, 1930: Under ether narcosis the tumor was again carefully palpated and, as it seemed to be more prominent under the posterior border of the sternomastoid the skin incision was planned accordingly. When the posterior fibers of the muscle had been freed by blunt dissection and the body of the muscle retracted mesially, the tumor was found to be within the carotid sheath. This was opened and, the true nature of the growth now being manifest, slow, careful blunt

* From the Department of Surgery, University of Illinois School of Medicine. Presented before the Chicago Surgical Society, December, 1930.

dissection was carried out at the point of bifurcation of the carotid artery. Remembering Chassaignac's tubercle, we felt confident that we could rapidly compress the carotid against it should the necessity arise. It was noted that the external carotid was indented as a result of the constant pressure of the tumor. The nutrient artery with the ligament of Mayer was ligated. The adventitia of the carotids remained intact. The incision was closed without drainage; the operation lasted fifty minutes.

Postoperatively, the patient had a rise in temperature to 100°F. on the second day and complained of slight headache and pain in the neck. No mydriasis developed at any time. The skin stitches were removed on the eighth day and the patient returned home on the tenth postoperative day.

Pathological Report (Prof. Jaffé): This specimen consists of a piece of tissue 3 × 3.5 × 1.5 cm. It is soft connective tissue in which are imbedded four firmer nodules, three of which seem to be loosely connected to one another. On section these firmer areas are a yellow-grey color, very poorly defined and without definite boundaries.

Microscopical: The tumor is composed of alveoli of delicate polyhedral cells and single very large cells with hyperchromatic nuclei.

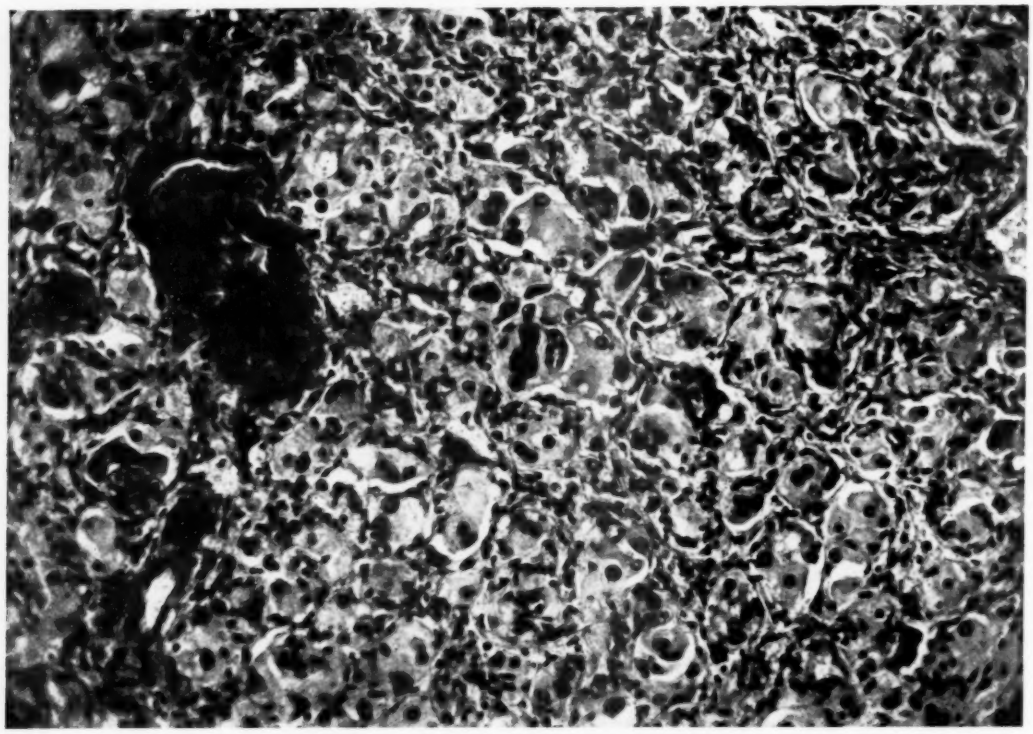

FIG. 1. Photomicrograph of carotid gland tumor.

Broad septa of a dense connective tissue with numerous mast-cells subdivide the tissue into lobules. In this stroma bundles of nerve fibers are found.

Diagnosis: Carotid gland tumor.

Our patient has reported for observation on several occasions and sixteen months after the removal of his tumor there is no sign of a recurrence and he is free from all symptoms.

That carotid body tumors are being recognized more frequently than in the past is evidenced by the fact that Wellbrock was able to collect 196 cases up to April, 1931, 53 new ones since the Bevan-McCarthy report of December, 1929. Statistics notoriously lend themselves to varied interpretations but, of the 36 cases reported in the literature during the period 1920–1928, we find that in 13 cases (36 per cent) the surgeon was able to enucleate the tumor without blood-vessel ligations. *Per contra*, among the 97 cases reported during

the period 1880–1920 only 18 (18 per cent) were removed by blunt dissection alone. Pursuing our statistics still further, we discover that approximately 50 per cent of the reported cases of carotid body tumor operations in 1930–1931 were enucleations. One may fairly safely conclude that, with improved technique and gentle perseverance 50 per cent of these tumors can be safely removed without damage to the carotid vessels, internal jugular or vagus nerve. Ligation of the external carotid alone does not, apparently, increase the mortality rate. There are records of 13 such ligations; deducting from them 2 cases in which death could be directly traced to vagus nerve injury, there was no operative mortality in the series.

PATHOLOGY

There would seem to be little or no agreement regarding the exact morphology of carotid body tumors and much divergence of opinion concerning their malignancy. Bevan and McCarthy state that "the majority of these tumors are not malignant and the patients live for twenty or thirty years or longer with tumors of the carotid body without ever becoming malignant or without their producing symptoms of moment." Rankin and Wellbrock report 6 malignancies out of 12 cases (50 per cent). Romanis and Michiner believe that:

> The carotid body is probably derived from the column of cells which ultimately develop into the sympathetic ganglia. It gives rise to two varieties of tumor:
>
> 1. Simple, highly vascular, slow growing growths which are, microscopically, peritheliomata;
>
> 2. Very malignant growths (potato tumor of Hutchinson). Microscopically these potato tumors consist of a cellular fibrous stroma which is not very vascular and contains irregular endothelial-lined alveoli, with occasional single nucleated giant cells in them. Such a tumor is often intimately attached to all three carotid arteries, while the internal and external vessels wrap around it and indent it, so as to give it a waist, and its rate of growth varies considerably. Sooner or later it will implicate the sternomastoid, jugular vein, vagus or sympathetic. It gives rise to a large lobulated, ovoid swelling, stony hard and under the upper third of the sternomastoid. It is painless and does not involve the skin. These same authors class carotid body tumors with locally malignant tumors of connective tissue such as endotheliomata and myelomata. An especial variety, arising in connection with the tunica adventitia and showing solid columns of cuboidal cells lying around vascular lumina in a fibrous stroma, is known as a perithelioma. Such tumors are found in the parotid gland (mixed parotid tumor), submaxillary gland and carotid body. Hutchinson named the latter a "potato tumor" from the peculiar greyish translucent appearance on section.

Many pathological reports of carotid body tumors fail to mention the presence of nerve cells; a few record the occurrence of giant cells. Gask and Wilson believe that these tumors are "developed as an offshoot from the sympathetic and contain cells which, like the medullary portion of the suprarenal body, are stained brown by chromic acid. A carotid gland may become the seat of a new growth, very variable in malignancy. The malignant forms rapidly infiltrate neighboring structures and are essentially inoperable." Winslow states that the carotid body is not a gland in the usual sense of the term; considered mildly malignant in its early development it tends, later in life, to undergo carcinomatous changes. Bundles of nerve fibers are always present.

Lung suggests four embryological derivations: (1) epithelium of the pharynx; (2) blood-vessel walls; (3) nerve tissue; (4) sympathetic ganglion cells of the carotid plexus.

DIAGNOSIS

Because of its rarity, an exclusive preoperative diagnosis is seldom made. The findings leading to a correct interpretation

of the nature of the tumor can be conveniently divided into (a) essential, (b) occasional.

(a) Essential:

1. A solid tumor of long standing, situated in the anterior triangle of the neck, at or near the apex of the submaxillary triangle. In size, it varies between that of a hazlenut and a hen's egg.
2. Movable laterally, but not vertically.
3. Non-expansile pulsation.
4. Not adherent to the overlying skin except in the very malignant type.

(b) Occasional:

1. Bruit and thrill on auscultation and palpation.
2. Bulging of pharyngeal wall if the growth is very large.
3. Dilatation or constriction of pupil on side of growth, depending on degree of sympathetic irritation.
4. Tenderness on deep palpation.

TABLE I

DIFFERENTIAL DIAGNOSIS OF CONGENITAL MALFORMATIONS OF THE NECK

Tumor	Age	Location	Single or Multiple	Density	Superficial or Deep	Motility	Fluctuation
Branchiogenic cyst	Congenital	Anterior triangle of neck	Single	Soft	Superficial; may extend deeply	Movable unless infection has occurred	Present
Thyroglossal cysts	Congenital	Median line below hyoid	Single	Soft	Subcutaneous	Freely movable	Usually present.
Lumphadenitis	Youth	Anterior or posterior triangle	Multiple as a rule, often matted together	Hard at first, later softer	Both as a rule	Slight or absent	Absent early.
Carcinoma	Aged	Depends on site of primary focus	Multiple nodes	Stony-hard, except in late cases with sinus formation	Deep	None	o
Sarcoma	Youth or early middle life	Angle of jaw, sternomastoid	Multiple nodes	Softer than carcinoma	More superficial than carcinoma	Early motility	o
Fibroma	30–45	Very rare in this location	Usually single	Hard	More superficial	Freely movable	o
Lipoma	Any age	No anatomic boundaries; not uniform	Single or multiple	Doughy or "woolly" soft	Superficial	Movable in all directions	o
Hodgkin's disease	10–40	Bilateral as a rule	Multiple, in chains or discrete	Softer than malignant tumors, harder than tubercular glands	Feel like lipomata but are more deeply seated	Movable	o
Syphilis	Any age	Submental or submaxillary glands. Look for chancre	Single or multiple	Hard, painless, adherent	Both	Early lost	o
Hygroma	Congenital	Inferior maxilla to clavicle; may pass to axilla or anterior mediastinum	Multiple; there may be as many as 100 pockets	Soft	More superficial than carotid body tumors	None	May fluctuate; impulse on coughing.
Aneurism	Middle age especially	Carotids especially	Single, usually fusiform	Soft	Deep as a rule	Usually none	None
Carotid body tumor	20 to 50 in 75 per cent of cases	Under sternomastoid or at its anterior border	Single, egg-shaped discrete	Firm but elastic	Deep	Lateral motility but no vertical motility	None.

5. Attacks of syncope from vagus compression.
6. Late paresis of one vocal cord.
7. Tingling sensation in neck.

DIFFERENTIAL DIAGNOSIS

As the writer has been unable to find a more comprehensive table, he feels justified in reproducing the one he evolved in 1916 (Table 1):

TREATMENT

The ideal treatment is surgical dissection of the tumor, a slow, painstaking and very delicate operation. Its success largely depends on recognition of its nature and location within the carotid sheath as soon as the skin and cervical fascia have been incised and retracted. If the surgeon is unduly fearful of tearing one of the carotids or the jugular vein, he will wisely throw a provisional ligature around the common carotid and have an assistant ready to tie the knot should the accident occur. Better still would it be for the operator to previously identify the anterior tubercle of the transverse process of the sixth cervical vertebra (Chassaignac's tubercle), and be

Table 1 (*Continued*)

Gurgling	Pulsation	Bruit	Specific reaction	Fistula	Course	History	Cachexia	Aspiration
None	None	None	o	May be present; may open in mouth or externally	Slow	Congenital	o	Clear or turbid fluid.
o	o	o	o	Rarely present	Slow	Congenital	o	Clear, thin light fluid.
None	o	o	Tuberculin	Late broken down sinus	Sub-acute	Tuberculous	o	Pus in late cases.
o	o	o	o	Only in terminal stage	Rapidly progressive	Primary focus	Present	o
o	o	o	o	Only in terminal stage	Progressive	o	Late	o
o	o	o	o	o	Chronic	o	o	o
o	o	o	o	o	Chronic	o	o	o
o	o	o	Blood picture, splenomegaly	o	Progressive	Irregularly progressive	Late	o
o	o	o	Wassermann positive	o	o	Chancre, etc.	o	o
o	o	o	o	Only after trauma or aspiration	Fairly rapid; extends between fascial layers esp.	May begin as a single cyst, but spreads rapidly	o	Clear, thin fluid.
Present	Expansile, delayed temporal artery pulse on affected side	Present	Wassermann positive	o	Fairly rapid	Syphilis	o	Fatal.
o	Present but not expansile	Present	o	o	Long history of slow growth	Rather sudden change to malignancy	Only very late	o

prepared to compress the common carotid against it.

The skin incision should parallel the sternomastoid muscle, either along its anterior or posterior margin, depending on which side of the muscle the tumor appears to be protruding.

Should the tumor be found to be irremovable except by section of all of the carotid vessels, the part of wisdom is to follow Bevan and McCarthy's advice, i.e. leave it alone. Ligation of the external carotid or of the external carotid and jugular vein is quite justifiable. Stewart makes the statement that: "A tumor which is found to be irremovable except by resection of portions of the vessels should be left, unless the condition of the patient warrants the severe operative risk. Syncopal attacks definitely due to the tumor, or evidence of malignancy, as shown by diminished lateral mobility, or by biopsy, would be the chief indications for this procedure."

Radiography has not been used in a sufficiently large number of cases to enable any definite idea to be formed of its value. Bevan classes his case as a cure, but only thirteen months had elapsed at the time of his report. Stewart and Birman both report failures under radium treatment and conclude that this method of therapy should be reserved only for those malignant cases which are inoperable, as its beneficial effect is too uncertain.

CONCLUSIONS

1. The successful enucleation of a carotid body tumor without traumatizing the contents of the carotid sheath is reported.

2. It would appear certain that 50 per cent of these tumors can be removed without vessel resection.

3. Ligation and resection of all three carotids is rarely, if ever, justifiable, the operative mortality being prohibitive. Ligation and resection of the external carotid, with or without removal of a section of the internal jugular vein, does not increase the operative mortality and is not followed by dangerous circulatory disturbances.

4. Radium treatment is still *sub judice* and should be reserved for inoperable malignant cases.

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SMALL FOREIGN BODIES IN THE EXTREMITIES

AN IMPROVED METHOD FOR THEIR REMOVAL*

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EVERY surgeon who has had experience with the removal of foreign bodies from the hands or feet, or the arms or legs of patients, realizes the difficulties which in one case or another will present themselves. The object is usually small, imbedded in soft tissues, but easily movable from its original situation by manipulation, pressure or squeezing. It is commonly of a dark color so that a single drop of blood in the operative field obscures it entirely. It is often so small that it is impossible to locate, unless the incision made for removal passes squarely across it. Often it cannot be felt by the touch of the gloved finger. The smaller the object the more difficult the search may be.

The more common radio-opaque foreign bodies are sewing needles, pieces of broken lead-glass, small chips of steel or other metal, short segments of wire, and grains of emery, in the hands or fingers; sewing needles or phonograph needles in the feet; insulin or hypodermic needles in the calf or thigh or in the arm.

Foreign bodies in the muscle tissue may do little or no harm if no infection takes place; often they can be left alone if the patient's peace of mind will permit it. But foreign bodies, however small, which are located in or near the tendons or ligaments of the hands or fingers are painful and interfere with the movements of the hand. Furthermore, blood vessels, nerves, or tendon sheaths can be permanently injured if they are penetrated. The functional organization of the structures of the hand is such that the slightest damage to certain parts may have permanent results. Even the minutest particle when situated in the hand may be very annoying to the patient. Usually he insists on having it removed. Foreign bodies in the foot are apt to be painful and a hindrance in walking.

It is our practice to remove all foreign bodies from the hands and fingers, and from the feet. From other localities we remove all those which are likely to be a menace to the patient.

When a small foreign body penetrates the skin and enters the deeper structures the wound of entrance frequently is so insignificant that it is indistinguishable from neighboring scratch marks, which are numerous on the hands of industrial workers. The patient may not know the exact location of entry. The direction in which the foreign body proceeded is even more difficult to establish. Often the offending object is located some distance from the spot in which it is first supposed to be.

The first and most important requisite to speedy removal of the foreign body is a knowledge of its exact location. For this purpose we stick two ordinary needles or pins through small portions of the epidermis in such a way that the pins cross each other at right angles. The point of crossing we place where we believe the foreign body to be located. These pins penetrate only the horny layer and cause no pain and no bleeding whatever if properly inserted. They must not enter the granular stratum. The needles must be clean but need not be sterilized. Figure 1 illustrates the procedure.

The next step is to take two *x*-ray views with the pins in place. One of these views is looking down perpendicularly

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on the point of crossing of the pins. The other view is taken so that one of the pins, preferably the transverse, shows in silhouette as a single point (see Figs. 2 and 3). If both of these views are accurately and carefully taken in this way, the visualization of the position and exact location of the foreign body becomes a simple matter, and the operation is rendered successful. Taking the case here presented as an example, we see that in Figure 2 the foreign body crosses the pointed limb of the longitudinal pin about 4 mm. from the crossing of the pins. One half of it lies in the lower left quadrant, the other half in the lower right quadrant. In Figure 3 we notice that the least distance between the pin and foreign body is about 3 mm., giving us exact knowledge of the depth at which it lies. Furthermore the combination of both of these views demonstrates to us the direction of the long axis of the foreign body.

By this careful step by step procedure it becomes an easy matter to visualize exactly the spot at which to make an incision that will come directly down on the foreign body when carried to the exact depth required and directed at right angles to its long axis. It becomes, in fact, more difficult to miss the object than to find it at the first attempt.

With the pins in place and the location and position of the foreign body firmly fixed in mind we take the patient to the operating room. The field is surgically prepared (with the pins still in place) and a tourniquet is applied to the base of the finger. In case the hand is involved a Martin bandage is run from the fingers to the arm and an Esmark constrictor applied above the elbow. When the foreign

FIG. 1. Photographic view of localizing pins inserted at right angles to each other into small portion of epidermis of left thumb.

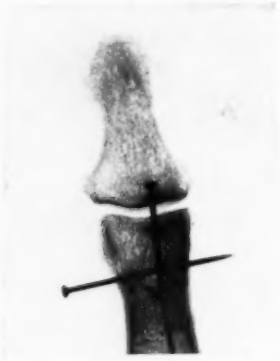


FIG. 2. Perpendicular *x*-ray view with localizing pins in place.

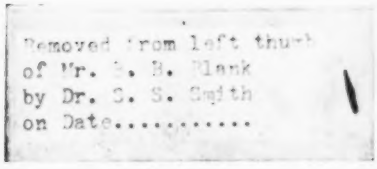


FIG. 4. Glass slide with foreign body and label affixed by adhesive tape.

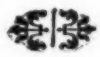
FIG. 3. Silhouette *x*-ray view of foreign body in extensor tendon of left thumb, localized by crossed pins inserted into small portion of epidermis.

body is in the foot the Esmark is placed above the knee. The object is to obtain an absolutely ischemic operative field, which is exceedingly important. If there is the slightest amount of blood present the foreign body will be obscured by it. The smaller the object and the more it approaches a spherical shape, the surer the operator must be to cut down squarely upon it. A miss of a millimeter can be enough to make an otherwise easy operation not only complicated and difficult, but protracted and tedious.

The pins are removed when the surgeon is ready to make the incision and after he has the exact point located where a minute incision will lay bare the foreign body. Usually a grating sensation can be felt as the blade passes over the foreign object. Retraction, if necessary, is best obtained by opening the blades of a curved Kelly forceps in the wound. In a completely ischemic field the dark foreign body is easily seen lying in the incision, and can be lifted out of the wound without manipulation or contamination of the tissues. We prefer to use general gas anesthesia. This insures complete relaxation, which is especially important when tendons or muscles are involved. The wound is closed with a single stitch, and dressed.

The entire operation, when carefully planned and properly executed, requires only a few minutes. At no time does the operator introduce his fingers or any other object into the wound except the few instruments he actually uses. The incision usually heals promptly by primary union. We have never found it necessary to resort to the use of a fluoroscope or an electromagnet.

In Figure 4 we show a convenient and simple method of filing away small foreign bodies in an ordinary slide box. The foreign body and a properly inscribed label are placed side by side on a microscope slide and an adhesive strip applied. We keep on file indefinitely those foreign bodies which might be called for as evidence in litigation proceedings.



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* Continued from page 260.

DIAGNOSIS OF ADVANCED ABDOMINAL PREGNANCY*

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IN a former article I reported a new method of diagnosing advanced abdominal pregnancy. Since that report of the first case I have used the procedure again with much help and desire to incorporate a report of the second case. I have seen no reference in the literature to the effect that the method has yet been used by others.

I desire again to call attention to the very great difficulty which often arises in differential diagnosis between intra-uterine and extra-uterine pregnancy.

To the physician who has not had several cases of advanced abdominal pregnancy to diagnose, it may seem that the diagnosis should not be difficult. True indeed there are some cases where the diagnosis is easy, but there are other cases where the previous methods of diagnosis have been quite insufficient and the obstetric attendant is left in serious doubt as to how to proceed with such cases.

Direct palpation of the abdomen is by no means dependable. I have seen several cases where superficiality of fetal parts seemed to indicate that the fetus was not within the uterus, in which subsequent vaginal delivery proved the lack of dependability of this sign. In many abdominal pregnancy cases the abdomen is so tender and rigid that instructive palpation of the fetus is precluded.

Have furthermore been called to see three cases where the introduction of a sound into the cervix failed to ascertain definitely whether the pregnancy was within or without the uterus. Even though the pregnancy may be extra-uterine, the uterus and its cavity are often much elongated so that the sound seems to discover a uterus much beyond the average non-pregnant size.

In each of these three cases a bag had been introduced into the cervix in an effort to obtain dilatation only to find that the fetus was not within the uterus.

The *x*-ray has failed me now in 8 cases. To be sure the *x*-ray shows the fetus, but it fails to demonstrate whether the fetus is inside or outside the uterus. It must be remembered that in abdominal pregnancy there is developed a false sac and some water, and the roentgenogram often shows this sac and water surrounding the fetus, but it looks too much like the normal pregnant uterus for a definite decision.

In my first case reported, the *x*-ray showed a fetus of approximately six months and a fetal heart beat was obtainable, yet the roentgenologist was quite unwilling to go on record as to whether the fetus was within or without the uterus. As the patient was in a serious condition it was quite necessary to arrive at a diagnosis. Iodized oil was introduced into the uterine cavity and the *x*-ray picture plainly showed the usual triangular uterine cavity as seen in non-pregnant uteri, thereby absolutely proving the fetus must be outside the uterus. Laparotomy was resorted to at once and corroborated the presence of an advanced abdominal pregnancy. (Details are published elsewhere.[1])

Since the report of this case another has come to my wards which presented the usual difficulties in arriving definitely at a diagnosis, there being much difference of opinion among consultants. An *x*-ray picture again showed a fetus of about seven months, probably macerated, but failed to determine satisfactorily whether the fetus was within the uterus or within the false sac of an advanced abdominal pregnancy. In view of the serious condition of the

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patient a definite diagnosis was very important. Iodized oil was introduced into the uterine cavity and an *x*-ray picture taken which quite conclusively showed a non-pregnant uterine cavity, leaving the only possible conclusion of advanced abdominal pregnancy. Laparotomy was done promptly and the diagnosis further confirmed.

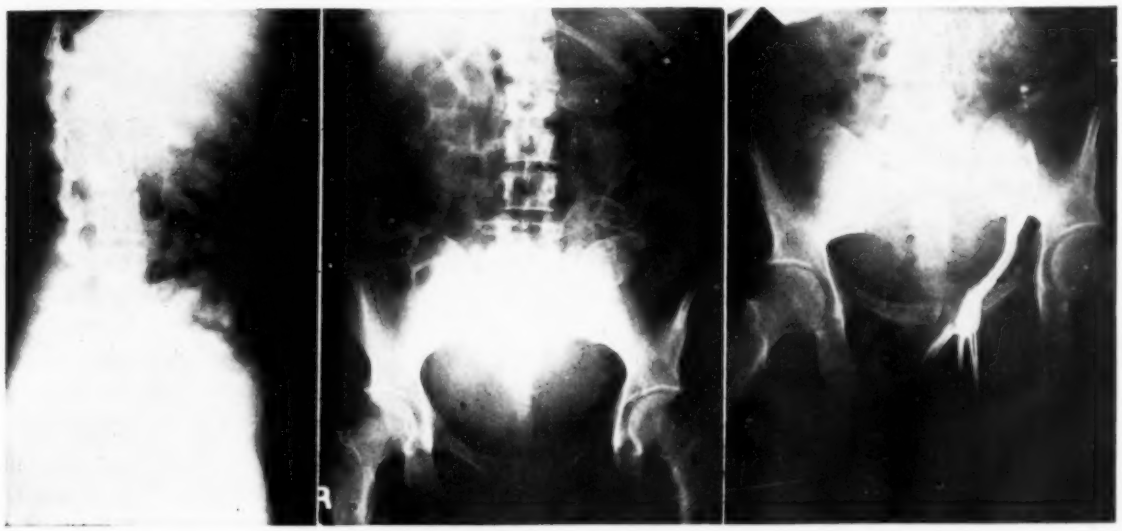

Fig. 1. Fig. 2. Fig. 3.

Fig. 1. Lateral *x*-ray showing fetal skeleton but giving no definite information as to whether fetus is intra-uterine or extra-uterine.

Fig. 2. Same patient as Figure 1; anteroposterior *x*-ray showing fetus but failing to demonstrate conclusively whether fetus is intra-uterine or extra-uterine.

Fig. 3. Same patient as Figures 1 and 2 after injection of iodized oil into uterus, showing usual triangular uterine cavity of non-pregnant uterus. Fetus can also be seen.

The introduction of iodized oil into the uterine cavity followed by an *x*-ray picture is by no means new. It is being done in thousands of cases for many conditions such as sterility, fibroid tumors, etc., and in a relatively few instances this procedure has been resorted to in an effort to diagnose normal uterine pregnancy,[2] but a search of the literature fails to reveal its use for differential diagnosis between uterine and extra-uterine pregnancy.

Such a procedure for the diagnosis of normal uterine pregnancy does not seem justifiable in view of the great danger of abortion,[3,4,1] and with the present development of the Ascheim-Zondek test for pregnancy it would seem quite unnecessary to resort to such an examination when the diagnosis can be so certainly established without risk.

But for the cases, of which there are many, which present serious difficulty in definitely determining whether the pregnancy is within or without the uterine cavity, the procedure herein reported offers a very dependable diagnostic means.

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END-TO-END APPROXIMATION & ACCURATE REDUCTION

AS A NECESSITY IN FRACTURE THERAPY*

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PHILADELPHIA

IN this day of the roentgenogram, that positive piece of evidence by which the surgeon is often misjudged, one is frequently confronted with the question of end-to-end approximation and necessity of accurate reduction in the treatment of fractures of bones. Many times conclusions are indefinite. Oft-times, despite careful and timely attempts at reduction, one is forced to accept an approximation that is anything but an accurate reposition of the parts involved. Immediately the question arises as to the ultimate result. Will there be firm union? Will there be deformity? What can one expect as to return of function? Will the patient be able to resume his previous occupation? These and many other questions the surgeon asks himself. He is interrogated to no end by the patient. It is needless to say that if all fractures were readily reducible, were easily maintained, and would unite firmly with an ultimate good result, satisfactory to patient and physician alike, this discussion would have no place.

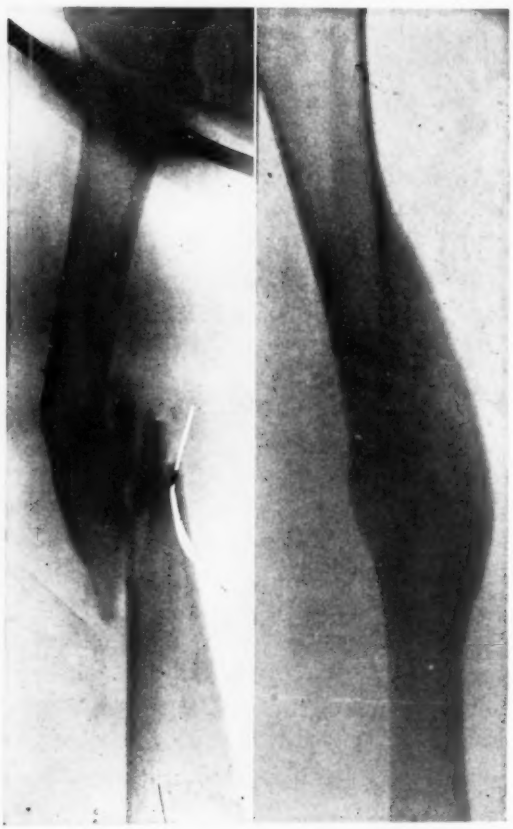

FIG. 1A. FIG. 1B.

FIG. 1. L. S., female, aged eighteen. Comminuted fracture of mid-shaft right femur. Automobile accident. View (a) day of admission Sept. 5, 1929. (b) Nov. 28, 1930, approximately fifteen months after injury. Traction therapy. No shortening and perfect functional result. Playing tennis.

AIMS IN FRACTURE THERAPY

The major aims in all fracture therapy are fundamentally twofold. One first attempts to obtain accurate reduction.[1] Accurate reduction as defined by the fracture committee of 1915 signifies anatomical restitution of fragments to the position they occupied before the fracture occurred, and their maintenance in that position until consolidation has taken place. Is it always possible to obtain accurate reduction? Can this aim be satisfied to its fullest meaning in all fractures? The reply is quite obvious.

The second consideration is the restoration of function. Of what use is a limb whose function has been lost because of injudicious attempts at reduction? What justifies added risk to life in the repeated induction of anesthesia? What justification is there for repeated mauling of a limb in attempts at accurate reduction, when by the anesthesia or these manipulations a life may be actually lost? It is a

* From the surgical service of Dr. E. L. Eliason at the Hospital of the University of Pennsylvania.
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known fact that repeated attempts at reduction oft-times result in non-union. As recently stated by Ashhurst:[2] "Mal-union of a moderate degree is less evil than non-union. It is better to leave moderate mal-union than to secure reduction at the expense of firm union."

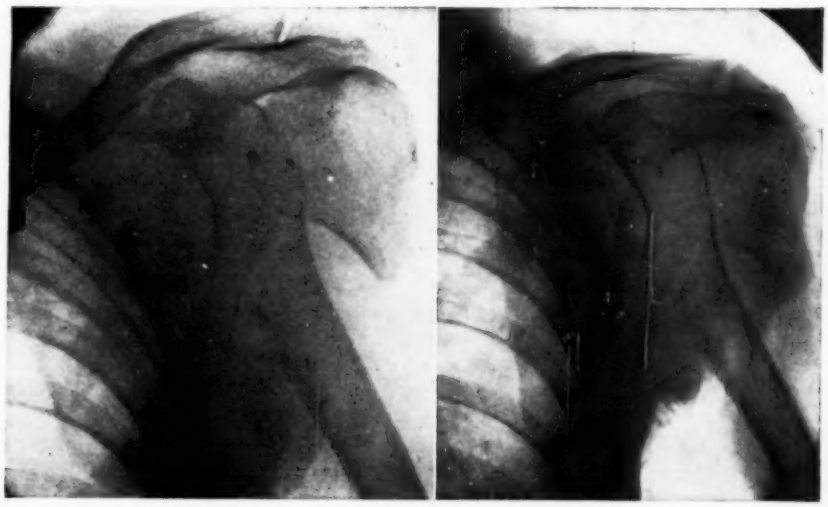

Fig. 2A. Fig. 2B.

Fig. 2. O., male, aged eighty-five. Fracture of surgical neck of right humerus. Cardiac decompensation and asthma precluded rational therapy. Treated in ambulatory manner with no reduction other than maintenance of axis. Back at work with comfort in six weeks. A. Immediately after fracture. B. Ultimate result.

METHODS FOR ATTAINING ACCURATE REDUCTION

The surgeon has at his disposal several possible courses of action to attain an accurate reduction. Briefly stated, these methods are: (1) Closed reduction, with or without fluoroscopic control, manipulation and locking of fragments, which are maintained thereafter by proper splints. (2) Open reduction with or without internal fixation, and in either instance maintenance of position by proper splints. (3) Continuous traction, commonly used in fractures of the femur, humerus and tibia. The assumption of any particular course depends primarily upon the individual fracture. The election of a method frequently is determined by one's limitations, lack of equipment and inability to perform open operation. When closed methods of reduction fail to bring position to accuracy, is one justified in recommending open operation, with its risks, both immediate and remote, to attain accurate approximation? Barring ordinary contra-indications to operation, when are we permitted to recommend open reduction?

SATISFACTION OF THE PATIENT

The general concept of fracture therapy has been altered to some extent by a public only too well aware of the possibilities of a malpractice suit. Often, despite personal negligence, the patient attempts to throw the entire blame of an injury with its incurred expense, coupled with the cost of maintaining his dependents for that period of disability, upon some second party. It matters little to him whether he is recompensed by an insurance company, a workman's compensation fund, or a physician through malpractice suit.

One must always strive to satisfy the patient. If the patient is dissatisfied by a deformity, mal-union or even slight loss of function, even though he has been warned at the onset of the treatment, he may turn on us with all the weapons of a recently acquired medical or legal advisor. The principal factors on which judgment may be based are the *x*-ray, with the roentgenogram as its permanent

record; the actual deformity and loss of function.

The most prominent weapon is the *x*-ray, which we have used to advantage in the actual diagnosis and treatment of the fracture, and which is now turned against us. The *x*-ray is responsible for more attempted open reductions than any other single factor. By the roentgenogram the position of the bony fragments can be accurately determined, and after reduction, by this means are we judged.

Very few reductions can be considered satisfactory, as one often discovers to his discomfort, unless controlled by *x*-ray examination, repeated as each case indicates. In the absence of the roentgenograms, actual deformity and loss of function are formidable weapons in the hands of a dissatisfied patient and unscrupulous lawyer. When the roentgenograms are available, deformity and loss of function may be interpreted in their light.

Fig. 3. H., male, adult. Fracture of upper third of radius. Illustrating failure to restore axis to normal, and to properly maintain reduction. Bad result.

Fig. 4. L. B., male, aged forty-seven. Simple fracture of upper third of shaft of femur. Buck's weight extension for six weeks. *X*-ray proved end-to-end apposition at that time. All extension then removed, and shortly thereafter patient complained of pain at site of fracture. Discharged from hospital without further *x*-ray examination.

Present view taken six months after accident, at which time patient applied to this clinic for operative reduction because of bowing and shortening of about 1¾ inches. Firm bony union made operative intervention inadvisable.

SUFFICIENT REDUCTION

What degree of reduction is sufficient? The answer is multifold, and depends upon (1) the site of fracture, (2) the age of the patient, and (3) the function required. In the long bones, namely the humerus, the femur, and the upper two-thirds of the tibia, and more rarely both bones of the forearm, the following criteria may be stated: (a) restore the axis of the fragments to normal, (b) prevent appreciable shortening, and (c) obtain bony

union. There are exceptions to these criteria which will be considered.

Figures 1 and 2 are illustrative of good results where the foregoing criteria have been satisfied.

Figures 3 and 4 are illustrative of poor results where the same criteria have not been satisfied.

Fig 5A. Fig 5B. Fig 5C.

Fig. 5. Male, aged thirty-six. Picked up by police in rum runner accident. Incarcerated. Prison physician applied a single forearm splint, not including elbow or wrist. Patient brought to hospital thirteen days later with result shown in A and B. Open reduction accomplished result shown in C. Patient was discharged with union five weeks later.

EXCEPTIONS

In the young, there is, especially in the long bone fractures, extensive remodeling and subsequent overgrowth of bone due to stimulation from the injury which often will compensate for shortening. Displacement is corrected under Wolff's law, in that "form depends upon function." The margins are more limited in the adult, as there is not such rapid and extensive remodeling, and according to Ashhurst[2] initial shortening of 1 cm. will be corrected, above which appreciable shortening will occur. Children more readily compensate for uncorrected deformities.

NECESSITY OF ACCURATE REDUCTION

Accurate reduction becomes more essential when the fracture line is near or involves a joint. Accurate reduction, at least end-to-end approximation, is most essential when one bone of the forearm is involved, becoming a necessity during the growth period. The areas in which accurate reduction must be carefully considered are: (a) At or near the shoulder joint. Exceptions enter here, because the movement of the scapula may compensate for loss of function of the shoulder joint.

However, no reasonable effort should be spared to secure accurate approximation. (b) Elbow joint, about the head and neck to restore the line of the wrist joint, which when disregarded results in a weak and oft-times useless wrist. (h) Both

FIG. 6A. FIG. 6B.

FIG. 6. Female, young adult. Supracondylar fracture of humerus (A) prior to closed reduction; (B) after reduction and application of suitable splint. Good result.

of the radius and displacement of the condyles of the humerus. (c) About the lower end of the radius, where deformity may interfere with function. (d) Intracapsular fracture of the neck of the femur, where non-union is apt to occur. (e) About the ankle joint, or lower one-third of the tibia, disregard of which may result in lasting disability from foot strain. In these fractures special attention should be focussed to the preservation of the mortise of the ankle joint and alignment of the astragalus with the tibia. (f) About the knee joint, although exceptions have been noted. (g) Where one bone of the forearm is involved, reduction is necessary bones of the forearm, so that function may be restored to a maximum.

Figures 5 and 6 are illustrative of good results where the foregoing factors have been observed.

RESPONSIBILITY AND THE PATIENT

It is again evident in the last group that all attempts at accurate reduction are aimed at preservation of function. The surgeon cannot be criticized when, failing to attain reduction of a fracture by the closed method, he advises open operation, knowing that he possesses the skill to improve the position of the bony fragments, and is then refused. The

responsibility there rests with the reliable patient or parent. When comminution of fragments complicates a fracture, open reduction is often questionable.

WRITTEN RECORD

In order that there may be no misunderstanding between the patient and surgeon a written record is most advisable. It has been our policy during the past few years to state exact aims to the patient. These objectives with their possible limitations are produced in writing, supported by reliable witnesses, and attached to the record. When possible the patient's signature is added. When, as in a fracture of a long bone, traction will satisfy our three aims (axis, length and union), the patient is so informed. If, when an open operation is advised, the objectives and the limitations are clearly stated, there can be no misunderstanding. Should a patient refuse an essential operation, he should be made cognizant of the probable ultimate outcome. These statements should be attached in writing with the patient's signature affixed. The responsibility at this point is most certainly his. When in doubt as to the necessity of accurate reduction or end-to-end approximation, it is much wiser to share the responsibility with one more experienced in the treatment of fractures.

POSSIBLE LIMITATIONS TO THERAPY

Aside from the fact that a fracture may in itself, because of its compound character, comminution or soft tissue injury, offer definite limitations to therapy, there are extraneous factors sufficiently important to merit consideration. These may be classed:[3] the patient, the surgeon and the operating room.

The Patient. Shock is the only contraindication to immediate reduction. No patient suffering from hemorrhage, cardiac, renal, hepatic or pulmonary disease or senility should be lightly subjected to actual operative measures. Difficulties may be surmounted by strict and careful preoperative preparation. The thoughtful selection of an anesthetic is quite essential. Alcoholism and drug addiction may be contraindications to operation. Pathologic fractures or spontaneous fractures should be carefully scrutinized to determine their possible etiology before subjecting them to actual operative measures.

The Surgeon. Experience is most essential in the surgeon. He should likewise possess ability and ingenuity. In this work as in any specialized field, an apprenticeship is most desirable. Extensive training can only be obtained opposite an experienced surgeon.

The Operating Room. Fracture work should only be undertaken when the operating room, including the force of assistants, nurses and orderlies are especially fitted for the work. Rigid asepsis is most essential. The Lane technique is desirable. The supply of instruments and apparatus must be complete and in working order. Operative work on fractures, especially where much traction and manipulation is needed, is extremely shocking to the patient, and time saved means lessened shock.

INDIVIDUALIZATION

Despite attempts to classify or standardize the treatment of fractures, each fracture is a law unto itself, and should be treated individually. The reduction sufficient for one who never uses his extremities cannot be compared to that demanded for one whose livelihood depends thereon. The risk to the patient must be justified by the objective. Individuality of treatment extends from the time of actual reduction with fixation to the resumption of full function. Individuality is required of the surgeon. The same individual should be responsible for the treatment of the fracture from the time of reduction to the resumption of function. The person caring for any fracture should personally review all roentgenograms made of that particular

fracture, before, immediately after reduction and as often thereafter as each case justifies.

To the patient, we cannot be condemned for giving justifiable advice; more often are we criticized for failure to give any.

SUMMARY AND CONCLUSIONS

1. That degree of reduction termed sufficient depends upon: (a) site of fracture; (b) age of the patient; (c)) required function.

2. In the long bones, namely the humerus, the femur, the upper two-thirds of the tibia and more rarely both bones of the forearm, the following criteria may be stated: (a) restore axis to normal; (b) no appreciable shortening; (c) obtain bony union.

3. Accurate reduction becomes more essential in the following areas: (a) near the shoulder joint; (b) at the elbow joint, head and neck of the radius; (c) lower end of the radius; (d) intracapsular fracture at the neck of the femur; (e) about the ankle joint; (f) about the knee; (g) one bone of the forearm; (h) both bones of the forearm.

4. Avoid legal complications by: (a) preoperative roentgenogram; (b) postoperative roentgenogram; (c) written record to contain the following essential points: (1) permission to treat; (2) actual statement of aims when operation is advised, with a summary of the possible limitations. Affix the patient's signature to his acceptance or rejection of such advice.

5. Definite limitations to therapy may be classed under the actual headings of the patient, the surgeon, and the operating room.

6. Fractures should be individualized from the following angles: (a) the patient, his occupation, (b) procedure of reduction; (c) fixation; (d) after-treatment; (e) the surgeon.

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WATER & CHEMICAL BALANCE IN SURGERY*

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SINCE water and sodium chloride are both essential to life, it is quite self evident that any deficiency in these elements beyond the minimal requirements will cause disturbances in the chemistry of the body, resulting in disease. In certain disease conditions, there is a loss of water and salt by the body, and a readjustment of these essentials will result in improvement or cure. It is important that careful attention be given to deviations from normal in the chemistry of the body as a part of all rational surgical treatment.

There is a definite circulation in and out of the upper intestinal tract that has great importance in the study and treatment of disease involving this region. Rowntree[1] has tabulated the quantity of secretions entering the intestinal tract in twenty-four hours, as saliva, gastric juice, bile, pancreatic juice and succus entericus and estimates that it amounts to 7500 and 10,000 c.c. This is two to three times the quantity ordinarily ingested by mouth, three to four times the quantity secreted as urine and about twice the total volume of the blood. It can readily be seen that any obstructing lesion of the upper intestinal tract, which prevents the reabsorption of the water and chemical elements secreted, may result in serious loss of essential constituents of the body in large quantity.

Of the disturbances incident to preoperative and postoperative treatment, the surgeon is chiefly concerned with dehydration, hypochloremia and acid-base balance. While it would be difficult indeed to tabulate the many roles played by water in the intricate chemistry of the body, it may serve for clinical purposes to point out some of the well-known functions which depend upon water balance. It has been shown experimentally that by starvation an animal can lose glycogen, fat and protein to 40 per cent of its body weight, but a loss of 10 per cent of the water content of the body results in serious disorders and a loss of 20 to 22 per cent results in death. The proper quantity is necessary for the normal functioning of every living cell. Generally this quantity is fairly constant. It plays an important role in heat regulation, physicochemical properties, such as solvent power, hydration, ionization, imbibition and surface tension, lubrication of serous surfaces, elimination and is essential for proper growth of the organism.[2] Sodium chloride is essential in maintaining acid-base balance, osmosis and water distribution, formation of hydrochloric acid and the gastric juice and may be a factor in maintaining the muscular tone of the intestinal tract[3] and in the proper growth of the organism.[4] According to Fleming[5] the bactericidal power of the blood is influenced by its sodium chloride content.

The clinical terms "alkalosis" and "acidosis" are often rather loosely used and frequently poorly understood. For practical purposes an estimation of the carbon-dioxide combining power of the blood will give the evidence necessary to indicate acid and alkaline changes which are important in the recovery from disease. To wait for an expert chemist to estimate changes in the hydrogen-ion concentration of the blood would be to postpone treatment until the patient reached extremis.

In a study of the water and chemical balance in preoperative and postoperative surgical conditions, dehydration, hypochloremia and acid-base balance must be considered together, since they are intimately associated in the pathological processes present and are treated together

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Table I

Alkalosis may be Suspected When There is (Cutting):

1. Dehydration
2. Blood concentration shown by increase of red cells and hemoglobin
3. Nausea and vomiting
4. Low blood pressure
5. Marked asthenia
6. Increase of blood non-protein nitrogen, urea and creatinine
7. Albumin and casts in urine.

Acidosis may be Suspected When There is:

1. Drowsiness and sluggishness
2. Irritability
3. Hyperpnea
4. Nausea and vomiting
5. Headache
6. Abdominal pain
7. Dehydration
8. Low urinary output
9. Cyanotic or cherry red lips
10. Convulsions
11. Coma.

as a group or symptom complex. Experimental dehydration[6] has shown a terminal rise in the non-protein and urea nitrogen, an elevation of the blood chlorides, an increase in the fibrinogen content of the plasma and an increase in the total protein of the blood serum. In acute high intestinal obstruction there develop pronounced chemical changes involving dehydration, hypochloremia and acid-base balance. There is an abnormal destruction of body protein as shown by the increase in non-protein and urea nitrogen in the blood. There is a change in the blood toward the alkaline side, as shown by an increase in the carbon-dioxide combining power. There

Table II

Conditions Showing Decrease in Blood Chlorides

1. Obstruction of esophagus and cardia (experimental)
2. Obstruction of pylorus
3. Upper intestinal obstruction
4. Gastric, duodenal and upper jejunal fistulae
5. General peritonitis
6. Pneumonia
7. *X*-ray
8. Severe burns
9. Anaphylactic
10. Gas poisoning (early stages)
11. Miner's cramp.

is a fall in the blood chlorides due to a loss of this element from the body. It is interesting to note that in obstructive lesions of the stomach and upper intestinal tract there develops an alkalosis as a result of vomiting and in infants an acidosis may develop, as a result of severe diarrhea. This is explained by the loss of hydrochloric acid in the first instance and loss of alkalies from the upper intestine in the second. Elman and Hartmann[7] have shown that a complete loss of the pancreatic juice will result in acidosis unless there is associated some vomiting to increase alkalinity by loss of acid.

Complete loss of the gastric juice[8] or complete loss of the pancreatic juice will result in death in a few days with changes in the blood chemistry similar to those found in high intestinal obstruction. Death will also result in two to five days with experimental complete drainage of the upper jejunum.[9] The similarity of the blood chemical changes in these conditions to those in intestinal obstruction leads to the conclusion that the cause of death in the latter condition may be due to a loss of the upper intestinal tract secretions by vomiting or accumulation in the stomach and upper gut.

Underhill and his associates[10] have made some interesting observations on the changes occurring in the blood in superficial burns. They have found that the blood becomes highly concentrated with a hemoglobin percentage that may be twice the normal. In spite of this extreme concentration of the blood, the chlorides show a decrease as noted by Davidson.[11] The importance of reestablishing the water and sodium chloride balance in extensive burns is obvious.

The low chlorides found in the blood and urine of pneumonia patients has suggested a replacement treatment with sodium chloride. Haden[12] and Sabatini[13] have each reported beneficial results by such treatment.

The rather startling observation by Rowntree[1] that animals can be intoxicated by giving them excessive doses of water and that this intoxication can be prevented or cured by administering hypertonic sodium chloride solution is an excellent

lesson in water and salt balance. Brockbank[14] describes a condition existing in miners, who are exposed to considerable heat, which he calls "miner's cramp." He attributes the cramp-like pains which are present in the arms, legs and abdomen to loss of water and sodium chloride by excessive perspiration. When such patients drink salt solution the cramps are cured or prevented.

In the treatment of any disease in which there exists a water or chemical imbalance it is obviously desirable to have some means of estimating the quantitative needs. The quantity of water loss is difficult or impossible to estimate accurately. The guides of most value are thirst, a knowledge of the daily intake, daily output in the urine, a knowledge of the quantity that it is possible to lose from the upper intestinal tract, and a determination of blood concentration by hemoglobin or hematocrit readings. If thirst exists and the patient has failed to ingest and excrete the normal quantities, water is, of course, needed to return these conditions to normal. Underhill[10] states that an animal or man cannot long survive blood concentrated to 140 per cent of the normal value. Quantitative estimations of the blood chlorides and acid-base balance can now be made with accuracy in the laboratory. In addition, study of the non-protein and urea nitrogen and the creatinine of the blood gives very valuable information concerning the condition of the patient and the prognosis. As long as abnormal readings exist in the blood chemistry, treatment is indicated. Such readings are, therefore, of great value as a therapeutic guide.

In the treatment of patients having obvious water and salt deficiency, it is not sufficient to instruct the assistant, intern or nurse to "force liquids," or to give saline solution. An accurate liquid chart, showing the daily intake and output, should be kept and in the very ill, blood chemical readings daily should be compared. The treatment instructions should, therefore, be based upon definite findings at the time and continue to be based upon the daily needs of the patient as estimated clinically and in the laboratory.

Any acid-base disturbance is so intimately associated with water and salt imbalance that the treatment of the latter usually suffices to correct the former. The alkalosis which develops in pyloric and high intestinal obstruction is relieved by giving sodium chloride solution. In acidosis glucose is added to the water instead of, or in addition to, sodium chloride. The administration of a solution of sodium bicarbonate to relieve acidosis and acid sodium phosphate to relieve alkalosis is rarely necessary and not without danger unless very carefully controlled.

The quantity of water, salt or glucose necessary to restore balance, obviously depends upon the need of the patient at a given time. In extreme dehydration, as a result of long water deprivation or persistent vomiting over a long period of time, the initial supply of water should exceed several times the average daily intake. Extreme sodium chloride loss should be promptly corrected by administering a hypertonic solution of this salt in sufficient quantity to restore the blood chlorides to within normal limits. Following this initial treatment within the first twenty-four hours, the normal balance may usually be maintained by administering physiologic sodium chloride solution, glucose solution and tap water.

Distilled water and tap water should not be used under the skin or in the vein. A 1 or 2 per cent sodium chloride solution or a 3 per cent glucose solution may be given satisfactorily by hypodermoclysis. Concentrated solutions given rapidly under the skin may cause sloughing. The administration of distilled water alone is of little clinical value when there exists a marked disturbance of sodium chloride or acid-base balance.

To maintain water balance in the average postoperative patient for the first few

days, a minimum daily intake of 3 liters of liquid may be satisfactorily used as a working basis. This is slightly in excess of the normal average daily adult intake. It may be necessary to increase or decrease this quantity, depending upon the clinical condition and progress of the patient.

In acute conditions with vomiting and low blood chlorides, salt therapy may be started with 500 c.c. of a 5 per cent solution given in the vein. This quantity, supplemented by physiologic salt solution under the skin, in the vein and by rectum, given in sufficient quantity to supply the water needed, will usually suffice to maintain sodium chloride at a normal level in the blood. Excessive quantities of sodium chloride solution may produce general edema. For the treatment of acidosis and to furnish food, glucose may be satisfactorily given intravenously in 10 per cent solution alone, or in combination with salt solution. In no sense is glucose a substitute for sodium chloride in the treatment of disease in which there exists a hypochloremia.

Generally speaking, it is wiser to give hypertonic intravenous solutions in doses not exceeding 500 c.c. However, continuous "venoclysis" may be given, providing the rate of inflow is very slow. The work of Hirshfeld, Hyman and Wanger[15] has emphasized the importance of giving intravenous solutions very slowly to avoid what they have termed "speed shock." They believe that reactions rarely occur when intravenous therapy is given at a very slow rate. In accord with this viewpoint they recommend that a solution of more than 100 c.c. in quantity be given at the rate of 2 to 3 c.c. per minute and less than 100 c.c. at the rate of 1 c.c. per minute. For practical purposes we have found the following rates of intravenous administration quite satisfactory:

1000 c.c. of physiologic sodium chloride solution in 1 hour
500 c.c. of hypertonic sodium chloride solution in 1–1½ hours
20 c.c. of 10 per cent sodium chloride solution in 5 minutes
500 c.c. of a 10 per cent glucose solution in 1–1½ hours
50 c.c. of a 50 per cent glucose solution in 10–15 minutes

Continuous intravenous drip 30–60 drops per minute.

SUMMARY

In order to obtain the best surgical results each individual patient should be studied from the standpoint of water and chemical balance. Certain diseases, such as high intestinal obstruction and severe burns, which show marked water loss and chemical changes, are dependent for cure upon a careful estimate and correction of the water loss and chemical imbalance. To restore to the body its normal constituents, which have been lost by disease, is a most logical type of therapy.

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CARCINOMA OF THE PENIS*

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THIS case of carcinoma of the penis is of interest because of its apparent association with a circumcision.

Mr. F. G., a Porto Rican, forty-three years old, married, was first seen at the Urological clinic of the Long Island College Hospital on August 1, 1930 complaining of soreness of the penis. He gave the following history: He was circumcised ten months ago. Since that time the glans penis had been persistently red and tender, and would not heal. He had been unable to indulge in sexual intercourse since then because of the associated pain.

Examination revealed the glans penis to be entirely covered by a somewhat irregular, red, moist tissue resembling granulation tissue. This extended from the meatus to the region of the corona at which point the skin from the shaft of the penis was adherent. The glans was also found to be quite tender.

It appeared as though the mucous membrane of the prepuce had been adherent to the glans and that at the time of the circumcision only the skin had been removed.

He was advised to undergo an operation which intended to free the adherent granulation tissue and expose the normal surface of the glans. Six days later this was attempted under general anesthesia. A meatotomy was first performed because of a very narrow meatus. A line of cleavage was then sought for at the meatus, but this was almost impossible to obtain. By both sharp and blunt dissection this superficial tissue was separated from the glans and stripped back to the corona, exposing for the most part a smooth glans penis. The skin was then incised at the corona, freed for a distance of one inch, and sutured to Buck's fascia just proximal to the corona. This left the glans with a free corona. When the patient was discharged six days later, the surface of the head of the penis had begun to show the formation of epithelium. Two months later he was able to indulge in intercourse without pain or discomfort.

He was kept under observation in the clinic and on September 18, just six weeks after the operation, a warty growth on the left and dorsal region of the tip of the glans was noticed. It gradually increased in size and hardness until in January, five months following the plastic operation, it covered an area 2.5 by 1 cm. This was markedly indurated and cornified, and was elevated about 3 or 4 mm. above the surrounding surface. On three separate occasions this growth was cauterized, but with little or no improvement. Later a biopsy specimen removed by the radiotherm knife was reported by the pathology department to be an epithelioma.

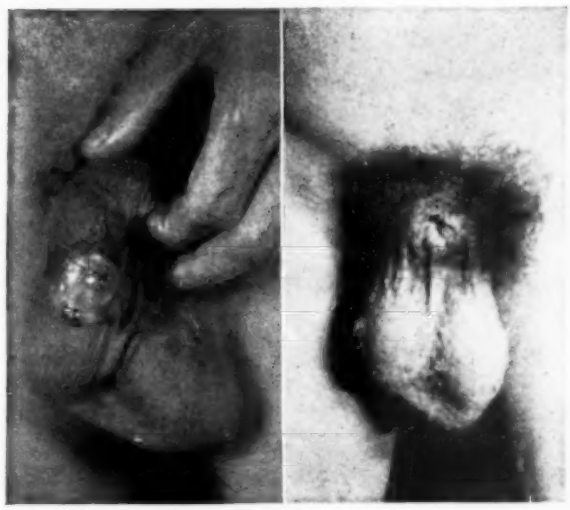

FIG. 1. FIG. 2.

FIG. 1. Epithelioma of penis. Lesion is at tip of glans.
FIG. 2. Nine months following partial amputation of penis.

Because of the localized involvement and the early stage of the growth, it was thought that a conservative amputation at about the midportion of the shaft of the penis would suffice to give as good a prognosis as a more radical procedure. And as there was no evidence of involvement of the inguinal lymph nodes

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surgery was preferred to either *x*-ray or radium.

On March 27, seven months following the previous plastic procedure, a partial amputation was performed under spinal anesthesia. This was done in the usual manner using the radiotherm knife to amputate the corpus spongiosum, and also the corpora cavernosa after the latter were ligated individually with chromic catgut. The skin was sutured in a vertical direction, and the urethra which was left somewhat longer than the corpora cavernosa was sutured to the lower angle of the skin wound. A winged tip catheter was placed into the bladder to divert the urine. This was removed after five days and the patient was then taught to pass a short glass sound daily to avoid stricture formation at the meatus. He was discharged from the hospital fourteen days following the operation with the wound healed except at the lower angle adjacent to the meatus.

Two weeks following his discharge from the hospital it was noted that the lower angle of the wound still remained unhealed. Because of the suspicious appearance of the tissue, a biopsy was performed. This was reported to be only infected granulation tissue.

Six weeks following the operation, deep *x*-ray therapy was begun as a prophylactic measure. This consisted of three courses of treatment totalling twelve exposures to both inguinal regions. This was completed last September.

It is now nine months following his operation. The stump of his penis although it may appear small in the photograph is able to carry on all its functions; he voids a good stream and is able to direct it, and he has satisfactory intercourse. The skin is still adherent to the distal end of the corpora which causes an upward bowing on erection; otherwise he has no complaints.

COMMENT: Apparently this patient at one time had an adherent prepuce and at the time of the circumcision the adhesions between the surface of the glans penis and the mucous membrane of the prepuce were not broken up, and only skin was removed. The new surface of the glans then became chronically infected and constantly irritated.

This may or may not have had a relationship to the carcinoma, but if irritation may be considered one of the etiological factors in cancer, we have a competent cause here.

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REPAIR OF CRANIAL DEFECTS*

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WITH our increased knowledge of the treatment of head injuries we are saving the lives of an increasing number of this type of patient. Many of these individuals, however, after recovering from their acute condition are doomed to a life of chronic invalidism or suffer various degrees of physical and mental impairment. To prevent or to combat these disabling sequellae following head injuries is one of our most important problems. One type of sequella that may be very disabling is the loss of a part of the cranium following a compound fracture of the skull. Many persons are struggling under this handicap of a cranial defect who could be easily relieved by a cranioplastic operation. This operation is so safe, so easy to perform, and in most cases gives such satisfactory results that every adult patient with such a defect should be given the benefit of a plastic repair. The two most generally accepted operations are here reviewed in the hope of stimulating a more frequent use of these procedures to rehabilitate this class of patients. While these operations are often tedious and time-consuming, they can be performed by the general surgeon. Moreover, they do not require special instruments or equipment. The results following the repair of a cranial defect are most gratifying, and I have yet to see a patient who, if not entirely relieved of his symptoms, was not at least benefited to a marked degree.

FIG. 1. Patient on admission to Robert Long Hospital.

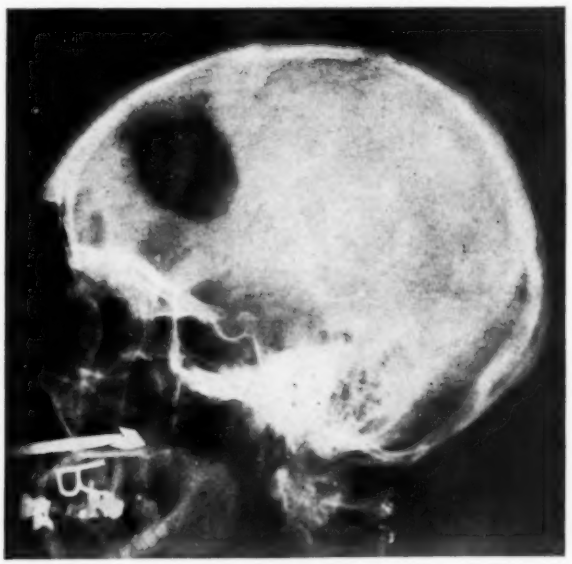

FIG. 2. *X*-ray of skull showing bone defect.

The most prominent symptoms complained of by patients with a cranial defect are headache and dizziness which becomes worse on physical exertion and with changes in barometric pressure. Some are greatly annoyed by the constant sensation of pulsation at the site of the defect. If the defect is over a motor area there may be attacks of Jacksonian epilepsy. Besides

*Submitted for publication November 27, 1931.

these physical symptoms there is generally a justifiable degree of neurosis due to the loss of part of the bony protection of the brain. The patient is in constant fear of being struck over his soft spot, and he fears leaving the shelter of his home. In the most stolid individual, feeling the pulsations of one's brain just beneath the scalp would be at least disquieting. The neurotic symptoms may be many and varied. In some patients the neurosis may show itself in the form of local or generalized convulsive attacks but it is seldom difficult to differentiate the neurotic from the Jacksonian type of convulsion. The patient shown in Figures 1 to 4 had a frontal defect, yet his chief symptom was general convulsions. These were probably in the nature of a defense mechanism as the attacks ceased after the closure of the defect.

Besides the symptoms and discomforts that may be complained of, the patient may also suffer embarrassment from disfigurement when the defect lies over the frontal or temporal areas.

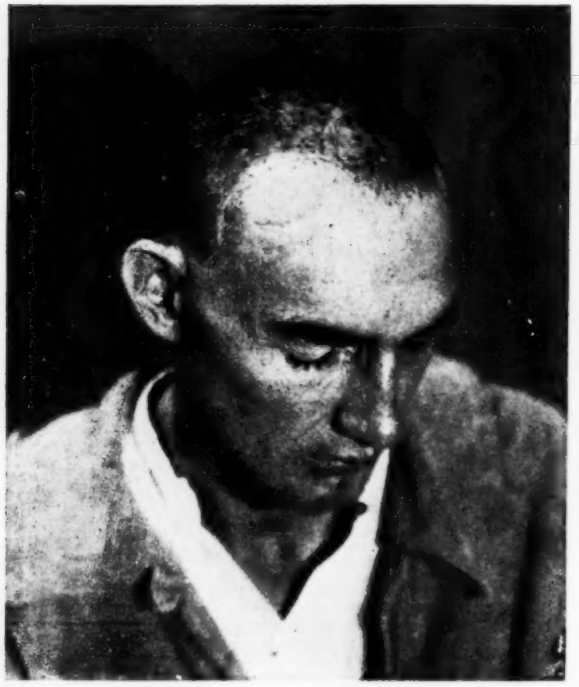

FIG. 3. Patient on dismissal.

The closure of a cranial defect is indicated in an adult who shows either physical or neurotic symptoms attributable to this defect, who is a fair operative risk, and who is free from acute infections or other defects that might interfere with the normal repair of tissues. The cranioplasty must not be done until the injury to the scalp has entirely healed. Discharging sinuses leading to pieces of necrotic bone call for a postponement of the plastic operation until all dead and infected bone has been removed and the sinus healed. Even an area of granulation tissue must be allowed to heal and become entirely covered with healthy epithelium.

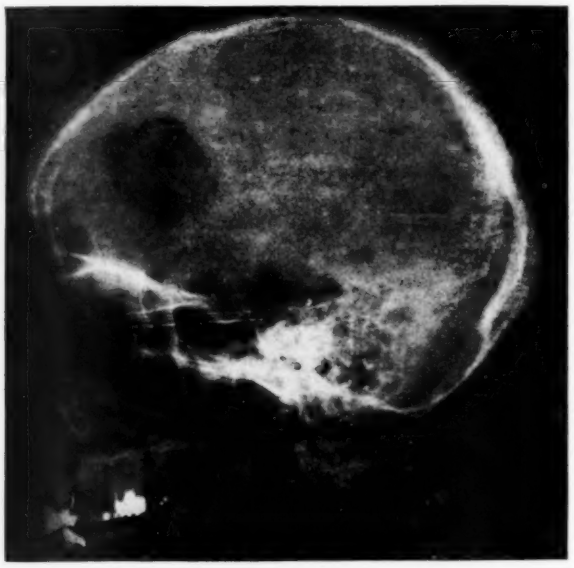

FIG. 4. *X*-ray of skull on dismissal.

Operations for the closure of skull defects are not only useful in cases where bone has been lost in compound fractures, but also in those cases in which portions of the skull have been removed on account of disease or neoplasm.

Defects of the skull in children do not require operative repair as young patients spontaneously generate new bone to cover their defects in the course of three to six months. Most of this new bone probably comes from the pericranium but I have seen patients who have undergone com-

plete regeneration of new bone who had lost a portion of their pericranium at the time of the injury. The tendency to spontaneous repair generally ceases with the sixteenth to seventeenth year of age.

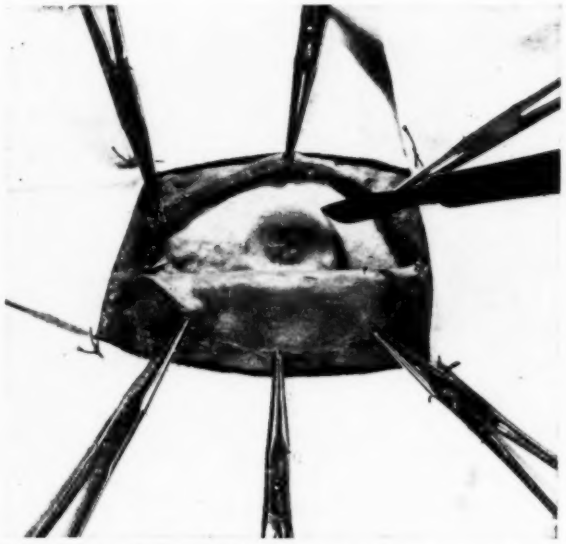

Fig. 5. Scalp flap turned back. Bone defect covered with pericranium exposed. Knife indicates point of incision in pericranium.*

Of all the various types of cranioplastic operations devised there are only two that are of practical value. In both of these operations a periosteal bone graft is used to cover the defect. The first type devised by Frazier[1,4] places the graft with the bone next to the dura. This makes a very neat closure, but it has one weak point, that is the bone is adjacent to the dura which is comparatively avascular. In the second type, devised by Bagley[2,3] the graft is reversed so that its bony portion lies next to the under surface of the vascular scalp. This second type does not lend itself to so neat a closure, but for practical purposes it is very satisfactory. I have always preferred Frazier's method, but in two cases there later occurred absorption in a part of the graft, followed by a return of symptoms. A second operation was then performed after the method of Bagley which resulted in a solid closure.

* Illustrations showing steps in operations were made from models.

Regardless of the type of operation to be done, the first step is to dissect away any thin scar tissue that might be present over the defect. If this scar is thick and apparently vascular it may be left as part of the scalp flap, but when the scar is very thin and adherent to the dura it must be completely excised. It is often difficult to separate this epithelized scar from the dura as planes of cleavage are generally obliterated. The next step is to make incisions in the normal scalp radiating from this denuded area in such a way as to expose the bone defect and at the same time plan for the closure of the scalp defect. These scalp incisions will vary with individual cases. The chief point to be kept in mind is that the graft must be covered with vascular scalp sutured without tension. In some cases in order to prevent this suture tension the scalp will have to be incised similar to a sliding graft leaving a denuded area of skull in another region of the head. This denuded area can either at the same time or later be covered with a Thiersch or other form of skin graft. In case the scar tissue about the defect is vascular and not too thin to interfere with the viability of the scalp flap a simple

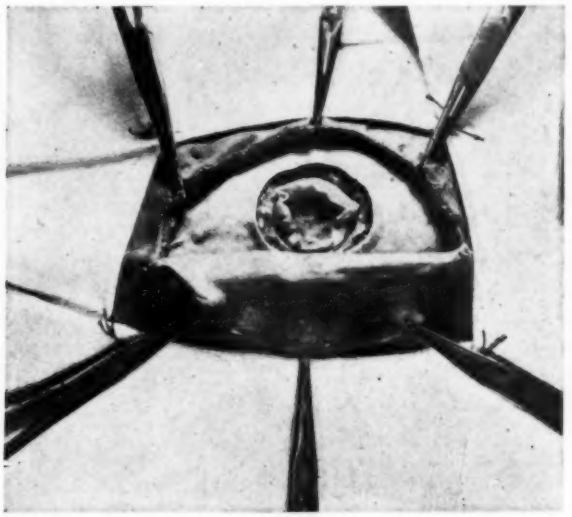

Fig 6. Pericranium elevated and defect prepared for graft.

semi-elliptical incision may be used extending to the pericranium (Fig. 5).

If the Frazier type of repair is to be done

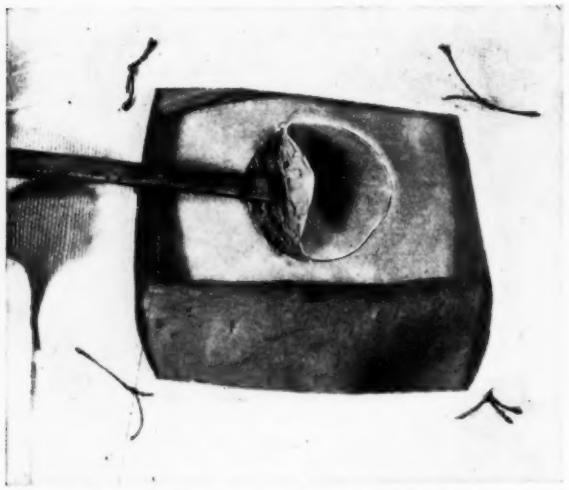

Fig. 7. Cutting pericranial bone graft.

the following steps are carried out: The scalp is incised and reflected to expose the pericranium covering the defect. With the point of a knife an incision is made in the pericranium surrounding the defect, about ⅛ inch outside the edge of the bony defect (Fig. 5). With a small sharp periosteal elevator the inner edge of the periosteal incision is separated from the edge of the bone as far as the inner surface of the skull. As a rule this can be done without tearing or opening the dura. If such an opening is accidently made no harm is likely to occur. Some advocate opening the dura and exploring the underlying brain but I see no reason for this unless one suspects an underlying cyst, loose fragments of bone or foreign bodies. After the pericranium is completely separated from the edge of the bone defect, this redundant membrane is folded in over the defect to help fill part of the dead space (Fig. 6). The outer edge of the cut pericranium is then elevated just enough to allow the introduction of sutures. Next, the edge of the bone defect should be examined for rough places or spicules extending towards the brain. These, if present, should be separated from the dura and removed with a rongeur. The outer edge of the bone defect is then freshened and beveled with a chisel or gouge. The defect is now prepared to receive the graft.

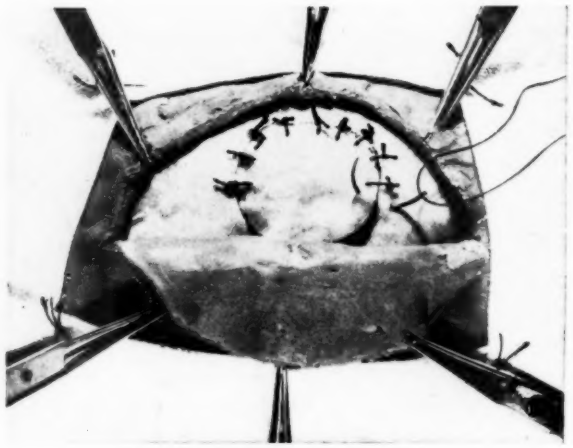

Fig. 8. Suturing graft in place.

The periosteal bone graft is best obtained from the parietal region, but other areas of the skull may be utilized if the circumstances make this more practical. If the defect is small the simplest procedure may be to extend the original scalp incision and to obtain the graft adjacent to the defect. If the defect is large it is generally best to expose the parietal region of the opposite side, making a semicircular incision in the scalp extending to the pericranium. To determine the size and shape of the graft a piece of thin sheet tin or lead is used. This must be thin enough to be very pliable. It is held over the defect and pressed down so that an imprint of the edges of the defect are obtained. With scissors the metal is trimmed about ⅛ inch outside the imprint of the defect. This metal pattern is then firmly held against the exposed area of skull from which the graft is to be taken, and with the point of a knife the pericranium is incised corresponding to the edge of the pattern. The pattern is then discarded. Through the circular incision in the pericranium a small chisel is inserted and the skull cut to the depth of about 1/16 inch, in order to outline the bony part of the graft on the bone. The next step is to use a sharp chisel with a ¼ inch cutting edge to obtain the bone

portion of the graft. This chisel is held in a very oblique position and starting at one edge of the circular cut in the bone the chisel is slowly and carefully driven under the disc of pericranium, chipping flakes of bone from the skull. These chips will vary in size and thickness. It is best to confine the bone chipping to the outer table for if the chisel penetrates the diploe it tends to go too deep and cuts chips too thick to be properly moulded. There is always a tendency for the chisel to go too deep and as soon as this is noted it should be withdrawn, the handle lowered, and chipping on a higher level resumed. If this chipping is properly done the chips of bone will remain attached to the under surface of the pericranium (Fig. 7). As the cutting of the bone proceeds the graft tends to curl upward. After it is entirely cut the graft can be moulded between the thumb and fingers to give it its normal contour.

The next step is to place the graft over the defect, the bone side next to the dura. The edge of the periosteum of the graft is then sutured to the edge of the pericranium about the defect by fine silk, interrupted sutures (Fig. 8). The scalp wound is then closed by two rows of interrupted sutures, deep and superficial. Fine black silk is very satisfactory. No drainage is required. If there is persistent bleeding from the skull where the graft was removed, this can be controlled by bone wax.

The second method of closure is by means of a hinged graft. In this method the graft is cut from the area adjacent to the defect, the pericranium being left uncut along the border where the edge of the graft and the defect meet (Fig. 9). The periosteal bone graft is cut as in the first method leaving a hinge of periosteum on one side. The graft is then folded over the defect, the bone chips being on the outer side. The pericranium of the graft is then sutured to the pericranium about the defect with interrupted silk sutures (Fig. 10). The scalp is then closed in the usual manner.

In order to make a neat closure with the hinge graft it is necessary that one side of the defect be in the form of a straight edge, otherwise it will be impossible to obtain a perfect pericranial hinge. The first time I attempted this method was in a patient with a circular defect; who, after a cranioplasty by the first method, showed a partial absorption of bone in the graft with a return of symptoms. A second operation was made by the hinge graft and when completed looked far from neat; nevertheless, the final result was a firm closure with a disappearance of symptoms. Confronted again with a similar case of

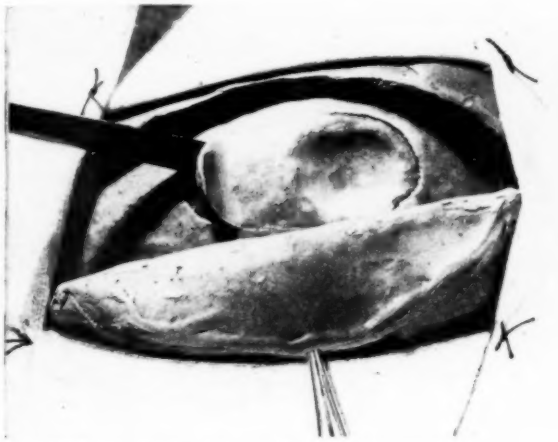

Fig. 9. Preparing graft in hinge method.

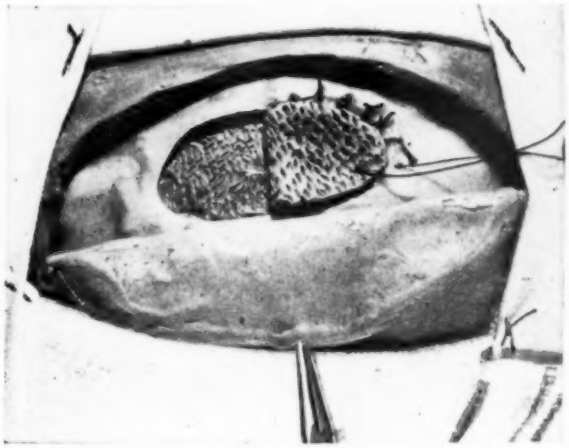

Fig. 10. Suturing hinge graft in place over defect.

absorption of the graft I would dispense with the hinge, cut the graft completely free from the skull as in the first method,

Fig. 11. Case B. C. Anterior-posterior view of defect on first admission.

and then suture the graft over the defect with the bone side out.

In the case cited here the hinge graft was of distinct advantage. In this case of the repair of a very large cranial defect there was an absorption of one side only of the graft. The edge of this secondary defect was almost straight which made it very easy to cut a long narrow strip of graft and turn it over the softened area.

There is a marked similarity in the history, complaints, and postoperative course of patients suffering from cranial defects. The latter case, however, showed some unusual features that warrants its report in detail:

Case 1. B. C., white, male, aged twenty-one, was admitted to the Methodist Hospital, Indianapolis, on May 30, 1928, complaining of left-sided epileptic fits and right-sided cranial defect.

The past history showed that five years before the boy was in a stone quarry accident when a large stone crushed the right side of the skull. The treatment at that time was the removal of fragments of skull through the scalp wound followed by closure of the scalp. Aside from some weakness in the left hand and a certain amount of fear on account of the large skull defect he considered himself recovered. Three years later he began to have twitchings in the left hand which gradually extended to the entire arm. This was soon followed by a similar twitching in the left leg and foot. The left hand then became spastic and paralyzed and he began to have typical left-sided Jacksonian epilepsy. These attacks

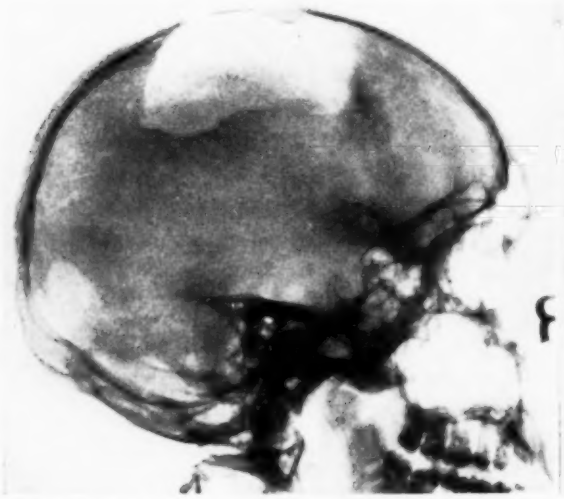

Fig. 12. Case B. C. Lateral view of defect on admission.

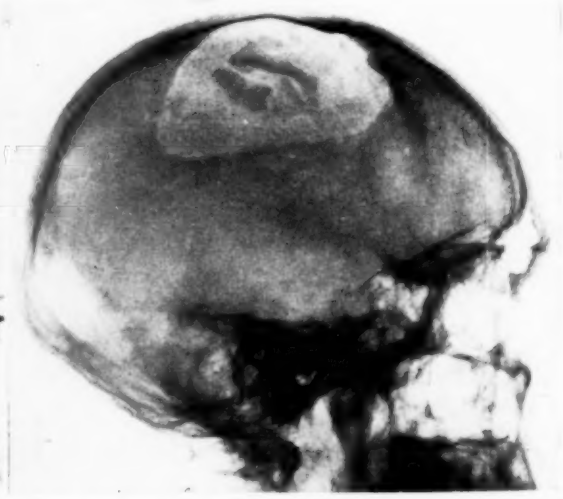

Fig. 13. Case B. C. Second admission showing partial absorption of graft.

gradually increased in frequency, and during the past three months before admission were occurring at intervals of fifteen to thirty minutes. He rarely lost consciousness during these attacks.

The remaining personal history was unimportant, and the family history was negative except that the mother was confined to bed with an active pulmonary tuberculosis.

Examination showed a well-nourished young man of apparently good intelligence. Over the right parietal area was the largest skull defect that I had ever seen in a living person (Figs. 11 and 12). When the head was raised there was a very marked depression, and when the head was lowered there was a marked bulging showing that the brain underwent considerable movement on changes in posture. Most of the scalp over the defect was replaced by very thin scar tissue. The patient suffered attacks of Jacksonian epilepsy involving all of the left side from the feet to the neck muscles. These attacks occurred at intervals of about every fifteen minutes. All drugs failed to modify these attacks to any noticeable degree. The left leg was spastic but not paralyzed. The left hand was paralyzed and held in the typical "claw hand" position. Further examination was essentially negative.

Operation: On June 6, a cranioplasty was performed after the method of Frazier. The graft was obtained from the opposite parietal region. With difficulty the graft was cut in one piece. The operation consumed four hours and the closure was satisfactory.

Subsequent History: The patient had one mild convulsive attack the day following the operation. This was his last and only epileptic attack for two and one-half years. The wounds healed per primam. He was discharged July 6. He walked out with a slight limp due to the spastic left leg. No improvement was noted in the left arm or hand. The cranial defect was perfectly solid to the touch.

About one year later he reported that he was married and making his living doing general work on a farm.

Second Admission: On December 13, 1930 he was admitted to the Robert Long Hospital, Indianapolis, complaining of a slight return of the Jacksonian attacks, and a softened area at the upper edge of the old defect (Fig. 13). Examination showed that there had been some absorption of the edge of the upper part of the graft about ½ inch wide through which pulsation could be felt. The remainder of the graft seemed perfectly solid.

Operation consisted in exposing the softened area only and covering this with a hinged graft which seemed ideal in this case. Wound healed per primam and all suggestion of epileptic attacks ceased. The patient was discharged four weeks after his admission apparently in good condition. While in the hospital he showed an elevation of temperature of about one degree daily. Tuberculosis was suspected as he had been exposed to this infection while living with his mother who had recently died, but examination failed to demonstrate this condition.

Third Admission: February 15, 1931. Four weeks after his last dismissal he was re-admitted to the Robert Long Hospital complaining of diarrhea and abdominal cramps. No history of epileptic attacks.

Examination showed the cranial defect firmly closed. General examination showed a marked degree of diffuse acute pulmonary tuberculosis together with acute tuberculous enteritis. He was discharged from the hospital March 9, 1931, unimproved. He died about six weeks later.

Comment: This case shows some interesting features. It is unusual to see such an extensive cranial defect, and it shows that there is probably no defect too large to attempt a closure. If a first attempt is not successful, repeated attempts will finally produce a solid skull.

In the past twenty-five years I have made many attempts to relieve patients with Jacksonian epilepsy using all methods described. With the exception of slight or temporary improvement all of these cases resulted in failure. In the foregoing case, the stopping of the attacks following the stabilizing of the brain within the skull by closing the defect makes me feel that the cause of the attacks may be due more to the motions of the brain from this instability than to the adhesions between the brain and dura.

[For References see p.295.]

OCCUPATIONAL THERAPY IN THE TREATMENT OF FRACTURES*

J. WILLIAM HINTON, M.D., F.A.C.S.

NEW YORK CITY

THE results from the treatment of different types of fractures that involve the joints have not been uniformly good; if the results were satisfactory there would not be such a diversity of opinion as to the method of treatment to be employed. I have had the opportunity to treat and observe a very large and varied group of fractures on the Fourth Surgical Division of Bellevue Hospital for the past eight years and the general conclusion one must draw is that the main objective is not necessarily anatomical alignment but rather the functional result and economic restoration. Unfortunately the tendency has been, due to the routine use of roentgen ray, to over-emphasize the anatomical result and minimize the earning capacity and functional result. It does not necessarily follow because the patient has a good anatomical alignment of the fracture that he will have a good functional result, and with the alignment not so perfect, but with a different type of treatment a much better functional result may be obtained and the individual restored to earning capacity much sooner.

FIG. 1. Patient filing wood to obtain wrist motion.

FIG. 2. Patient sawing which gives wrist, elbow and shoulder motion.

In this discussion it is not intended to advocate any particular type of treatment, as it is obvious that all types of treatment have a selected field of usefulness, and Dr. Carl G. Burdick, Director of the

* Read before the Medical Association of Greater New York, December 21, 1931.

FIG. 3. Patient weaving, giving flexion of elbow or knee.

FIG. 4. Patient is using a brace and bit for rotation of shoulder or pronation and supination of forearm.

FIG. 5. Patient weaving on circular frame for abduction and rotation of shoulder.

FIG. 6. Patient using a treadle saw for flexion and extension of ankle.

Fourth Surgical Division of Bellevue Hospital, not being satisfied with the results from the treatment of fractures, established a follow-up clinic in November, 1925 to evaluate the results from the different methods employed. After observing these patients for one year in the follow-up clinic it was felt that the results were not sufficiently satisfactory and the poor results seemed to result more from delay in treatment than from the type of treatment employed, so Dr. Burdick decided to have all fractures, regardless of type, treated as emergencies and immediately reduced, and at that time Dr. Lewis and I were assigned to the care of all fractures on the division; this routine was carried out for a two-year period. It was noted that by reducing fractures immediately after admission some of the problems previously encountered in difficult cases were simplified.

FIG. 7. Patient weaving to obtain abduction of hip.

FIG. 8. Patient doing cord knotting for flexion of hip.

During the past six years 1725 fractures have been treated on the Fourth Surgical Division. The majority of the joint fractures have been treated by immediate reduction with the application of a cast, or moulded splint, and the one exception has been fractures of the shoulder which have been treated by traction. It has been most unusual to have to resort to an open operation in any of the fractures, provided these patients upon admission were immediately *x*-rayed, and treatment instituted. One should remember that there is no 100 per cent satisfactory method of treatment to be employed in all fractures of a similar type, but the treatment has to be selected to fit the given case and if these cases are seen early and treatment instituted immediately, the difficult ones are made easier, while if treatment is delayed easy ones are frequently difficult.

The after-treatment of fractures is most important so as to shorten the disability and give a good functional result. During the first year the follow-up clinic was run different types of physiotherapy were used, chiefly baking and massage, with a moderate degree of success, but particularly in the joint fractures the results did not seem to be as satisfactory as one desired, and it was then thought advisable to institute occupational therapy in all types

of fractures that involved the joints, and with the cooperation of Miss Merritt, Director of the Occupational Therapy Department, the joint fractures have been referred to her since that time with most encouraging results. A detailed report[1] as to the methods used was made before the American Occupational Therapy Association in 1929 and those interested in the exact technique of treatment are referred to this work. All told there have been 1143 cases in the Occupational Therapy Department from the Fourth Surgical Division, which include 1101 fractures, and most of these have involved the joints, or were closely associated to a joint; there were 42 dislocations in the foregoing group. Miss Merritt feels that the results from occupational therapy alone have been better than in those cases in which the patient has received both physiotherapy and occupational therapy. The patients from the Fourth Surgical Division have received only occupational therapy, but some of the other divisions have employed physiotherapy and occupational therapy on alternating days which has given Miss Merritt an opportunity for her observations.

The illustrations represent some of the work done by patients with fractures involving the joints, and one can see the interest that the patient has in his work. Of course, there are three work periods, alternating with rest periods, and the work periods being two to three minutes and alternating with one to two minutes of rest. As the patient's condition progresses the work periods are increased and the rest periods shortened, and the type of work is changed so as to require more energy.

There are two reasons for selecting occupational therapy in preference to massage and other types of physiotherapy: The first is reestablishing confidence in the patient, so that he will use the injured part. It then soon becomes a competitive task and one tries to do as well, if not better than someone else with a similar injury doing the same work. Secondly, it is known that vigorous massage, in children, may produce myositis ossificans, particularly in elbow fractures. This has been demonstrated with roentgenologic findings. If this can happen in children it would seem that it might happen in adults to a lesser degree, and instead of the patient being benefited by prolonged massage his progress may actually be retarded.

If one observes the interest that patients put into their work, at the same time completely forgetting their injury, the benefit derived from this type of treatment in contrast to physiotherapy is obvious.

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*Continued from p. 291.

ADVANTAGES OF URETERO-INTESTINAL ANASTOMOSIS FOLLOWING NEPHRECTOMY FOR TUBERCULOSIS IN CERTAIN CASES*

A. R. Stevens, M.D., F.A.C.S.

NEW YORK CITY

I AM encouraged to draw attention to the advantages of ureteral transplantation into the bowel in dealing with certain patients who still have an intolerable urinary condition after nephrectomy for tuberculosis, because of my gratifying experience with two such personal cases so treated. Both patients were afforded immediate relief and at the end of two and one years respectively are at work, entirely comfortable and in excellent general condition.

Case 1.* An Italian girl, aged fifteen, was first admitted to the hospital March 5, 1926, complaining of pain in the back and right lower abdomen of four months' duration, but especially of marked frequency of urination which had become progressively worse the past eight months. Fortunately the child was a sound sleeper and the night frequency was practically incontinence. Hematuria had been noted for one week.

Examination: The patient was in fair weight and did not appear very sick. General examination, including lungs, was quite negative. There was slight tenderness in both costovertebral angles, more on the right side; the kidneys were not palpable. The urine was turbid, contained some albumin and considerable pus and blood; but no tubercle bacilli were found. Hemaglobin, 75 per cent; leucocytes, 8000.

Cystoscopy: Bladder capacity was only 1½ ounces. Urine very cloudy. Bladder showed marked general inflammation and bled easily. After several abortive attempts, the right ureter was finally catheterized and very turbid urine was obtained; this contained much pus but no tubercle bacilli were found in the stained slide; the urea percentage was 0.3, and indigocarmine given intravenously appeared in a trace only, after twenty minutes. The left ureter was not catheterized, but urine obtained from the bladder after thorough irrigation contained no pus; its urea percentage was 0.5 and indigocarmine appeared in seven minutes in deep concentration. A right pyelogram showed a non-rotated kidney with dilated calyces, some with an irregular contour indicating a destructive process.

Operation: On March 29, 1926, right nephrectomy under general anesthesia was done. The ureter was very indurated and nearly 2 cm. in diameter. It was cut across near the pelvis, as I thought the patient's condition did not permit complete ureterectomy. The kidney was of normal size, and contained many small abscesses; the histological report was tuberculosis.

On April 22, phenolsulphonephthalein output (after intramuscular injection) was 15 and 10 per cent for the first two hours. Operative recovery was satisfactory but the urinary frequency continued. Cystoscopy revealed general cystitis and ulcerations about the right ureteral orifice. Two applications of 20 per cent acid nitrate of mercury were made to these ulcers. Patient was discharged from hospital May 22.

She was re-admitted October 6, 1926, for five weeks, as the urinary frequency had become even more marked, often every five to ten minutes, and there was occasional hematuria. Cystoscopy showed tubercles about the right ureteral orifice and general cystitis. The left ureter was catheterized and clear urine obtained; microscopically there were only a few scattered leucocytes and no tubercle bacilli. The patient was discharged to a tuberculosis sanatorium.

*This is also Case 1 in article entitled "Pyoureter" by H. S. Jeck.[1]

* From the Urological Department, Bellevue Hospital. Read before the American Association of Genito-Urinary Surgeons, Buck Hill Falls, Pa., June, 1931.

She was re-admitted February 6, 1927, with no improvement of the urinary status. The cystoscopic picture was about the same and the bladder capacity was ½ oz. Remembering the condition of the ureter as found at the first operation, I suspected that this might be a fundamental cause of trouble, and on February 24, *removed the remainder of the right ureter* down to the bladder, easily drawing it under the broad ligament. I was amazed to find that the ureter had changed markedly in size and consistence; it was soft and pliable and no larger than a lead pencil. During this procedure the peritoneal cavity was entered, several ounces of clear fluid evacuated, and several loops of bowel studded with tubercles were noted. The bladder was palpated, was small and its wall seemed to be 7 or 8 mm. thick. The ureter showed microscopic evidence of tuberculosis. The convalescence was uneventful but the urinary condition was not helped by this operation. Patient was discharged March 27 to a sanatorium for tuberculosis. Bladder irrigations of some sort were tried with no relief.

Fig. 1. Case I. Intravenous uroselectan urogram, thirteen months after implantation of left ureter in large bowel. Operation was performed three years after right nephrectomy for tuberculosis.

Fig. 2. Case II. Intravenous uroselectan urogram, made three weeks after implantation of right ureter in large bowel. Operation was performed three years after left nephrectomy for tuberculosis.

Cystoscopy on May 16, 1927 showed general cystitis with some small ulcers on the left side of the bladder; two typical tubercles were seen. The bladder capacity was still small. Ureteral transplantation was considered at this time, but fearing extensive intraperitoneal adhesions, I advised further waiting.

In December, 1928, the patient was virtually incontinent day and night. Fortunately this did not seem to interfere with sleep and she held her weight. The bladder capacity was 1½ ounces and cystoscopy showed some improvement in the appearance of the mucosa in that there were no ulcerations or tubercles. Indigocarmine given intravenously appeared in ten minutes distinctly but not of deep color.

The patient's fifth admission to the hospital was on May 21, 1929. The situation had been

carefully weighed. The girl was one of eight children living with the two parents in a four room flat. Her bed was soaked with urine every night and pads were worn by day and she was unable to mingle with friends. She and her mother were quite willing to take any risk involved in a procedure which offered hope of relief.

On May 24, 1929, *the left ureter was transplanted into the upper rectum* through a left rectus incision extending from the umbilicus to the pubis. The rectum had been thoroughly irrigated just prior to operation. The work was begun under spinal anesthesia but general anesthesia was required later. On opening the peritoneal cavity, it was a great relief to find but few adhesions and no tubercles present. There was no evidence of tuberculosis of the fallopian tubes. The ureter was located at the junction of the internal and external iliac arteries and followed to the bladder. The overlying peritoneum was incised and the ureter cut across near the bladder with a carbolized knife; the lower end was tied and the upper clamped. The ureter was uniformly dilated, about 8 mm. in diameter. The small intestines were held in the upper abdomen by gauze pads. The anastomosis of ureter with large bowel followed closely the earlier technique of Coffey, no catheter being used in the ureter. The musculature of the bowel was dissected well back from the mucosa, affording ample space for the large ureter. This was held in place by the suture in the end of the ureter, brought out through the bowel wall about 1.5 cm. below the opening made in the mucosa to admit the ureter; its position was further fixed by including a little of the ureteral wall in the lowest of the five Lembert sutures of fine chromic gut closing the muscle and serosa over the ureter. A few reinforcing sutures were employed and the site of the fixation suture from the end of the ureter was similarly covered. The posterior peritoneum was carefully sutured and the abdominal wall closed in the usual manner, with a cigarette drain to the site of anastomosis. Care was employed that the ureter should follow an easy course to the bowel without angulation or any tension. A tube was left in the rectum four or five days after operation.

The ureter seemed dilated with urine at the end of the operation. I feared the closure of the bowel over the ureter may have been made too tight, and was prepared to do nephrostomy later. However, urine came from the rectum during the night after operation and 11 ounces were recovered the next day, and 40 ounces during the succeeding twenty-four hours. The temperature touched 102°F. the first postoperative day, but subsequently did not rise over 100°F. At no time was there any tenderness over the kidney. The patient made an excellent recovery and was discharged from the hospital nineteen days after operation with the wound healed. She had good rectal control, holding urine two to three hours and not wetting the bed at night.

Two months after operation the intramuscular phthalein test was 10 and 5 per cent, collections being made at the end of one hour and ten minutes and two hours and ten minutes. Six months after operation the phthalein test was the same, and the patient had gained 15 pounds.

A year after operation she looked and felt very well. Bowels usually moved easily, but patient occasionally took a little mineral oil. She rarely got up at night to urinate and held urine from two to four hours by day. There was no wetting of bed or clothes. Intravenous uroselectan urograms were made (Fig. 1) and show some dilatation of the ureter, probably more than existed at the time of operation. Eighteen months after operation, the phthalein output was 7 and 20 per cent for two hours.

Two years after operation (May 17, 1931) the patient was cheerful and doing daily clerical work. She had no complaints and was urinating every two to three hours when standing but held urine four hours when sitting. She frequently sleeps all night without interruption and never gets up to urinate more than once. When exercising strenuously she occasionally leaks a little urine, otherwise the control is perfect. Intravenous phthalein test shows 5, 10, 10, and 5 per cent for the first four half-hour periods. Intramuscular test was done for comparison with earlier reports; it was 10 and 15 per cent for two one-hour periods. These certainly show no diminishing renal function, but rather an improvement since operation.

Case II. An Italian man, aged thirty-six, was admitted to the hospital March 17, 1930,

complaining of frequency of urination and dysuria. Two years earlier his left kidney had been removed for tuberculosis. But the urinary distress really became worse and for five months after operation there was also occasional hematuria. At time of admission, urination was at intervals varying from fifteen minutes to one hour. There was almost a constant desire to empty the bladder, and the patient frequently bent double with straining and pain during the act.

The family history was negative for tuberculosis, and the patient's own past history was irrelevant except as stated.

Examination: The patient was a small, thin, undernourished man, weighing 97 lb., and appeared worn out from loss of sleep. We could find no evidence of an active tuberculous process anywhere outside the urinary tract. Radiograms of the chest were negative and examination of abdomen and genital tract was likewise negative. The urine showed a trace of albumin and much pus. No tubercle bacilli were found on three microscopic examinations. The Wassermann test was negative. Six blood examinations showed non-protein nitrogen varying between 33 and 42 mg. per 100 c.c. of blood, and creatinine between 1.6 and 2.2. Phenolsulphonephthalein test (intra-muscular injection) before operation, varied between 15 and 30 per cent and 35 and 20 per cent for two hours. This certainly precluded any marked tuberculosis of the remaining kidney.

Cystoscopy: The bladder capacity was not over 2 ounces. There was general cystitis with few small ulcerations on the right posterior wall. The right ureteral orifice was large but would admit no catheter over 2 cm.

The patient was given six weeks' treatment of the bladder, trying irrigations and also phenol instillations. These seemed to lengthen the average intervals between urinations, but the longest was never over one hour. However, the pain continued to be severe. The temperature was elevated at times, but an afebrile period was chosen for operation, after two postponements.

Operation: On April 29, 1930, *transplantation of the right ureter into the upper rectum* was done through a midline incision, under spinal anesthesia. The technique employed was virtually the same as in the first case. The ureter was soon found, and proved to be nearly 2 cm. in diameter. The large bowel was not over 3 cm. in diameter, so that the job looked formidable. However, after the ureter was cut across and allowed to empty, its size diminished markedly. The urine collected was later examined and it contained only an occasional leucocyte; no tubercle bacilli were found. The muscular layer of the bowel wall was dissected widely to make room for the large ureter. Two of the Lembert sutures grasped a small bit of ureteral wall, care being taken to avoid blood vessels. A second layer of Lembert sutures was placed over the first layer and over the ligature in the bowel wall coming from the end of the ureter. Care was exercised that the ureter should follow an easy course without angulation or tension. The posterior peritoneum was carefully sutured, and the abdomen closed without drainage. As in the other case, a tube was left in the rectum for about five days.

Urine came from the rectum the day after operation and there was a good output daily thereafter. Three days after operation the non-protein nitrogen rose to 48, but soon dropped to normal. The temperature reached 103°F. on the third postoperative day, but was not above 100°F. afterwards. In two weeks, the patient was passing urine every two or three hours, about 7 ounces at a time. There was no tenderness noted in the kidney region at any time. Urograms were made after giving uroselectan intravenously, nineteen days after operation. These showed dilatation of the ureter (Fig. 2), about as would be expected from the operative findings. Twenty-two days after operation the patient left the hospital, with the wound healed and a gain of 4 lbs. in weight.

Six months later, he weighed 115 lb. (a gain of 18 lb. since operation), had no discomforts and controlled the rectum day and night. He did not drink much water and hence emptied his rectum only four times in twenty-four hours. He would notice a little pain for a few minutes occasionally, in the right costovertebral angle, "on cloudy days." A year after operation (May 17, 1931), he reported that he could sleep continuously for seven to eight hours, and urinated by day only once in five or six hours, always having a good control. He was feeling well and working everyday as a clerk. His weight was 116 lbs.

Phenolsulphonephthalein test (intravenous) was 5, 10, 5, and 10 per cent for the four succeeding half-hour intervals.

It is a matter of common knowledge among urologists that the change in urinary symptoms following nephrectomy for tuberculosis cannot be predicted. If frequency has been of short duration, it may cease quickly. But with a long history and tuberculous involvement of the bladder, no improvement may be noted during the stay in the hospital. In some instances, with proper and prolonged hygienic care including heliotherapy, the patient may become entirely comfortable in time. Indeed, such care should be urged upon all patients following any surgical operation for tuberculosis. Those individuals with continued bladder symptoms after nephrectomy should also be given the benefit of instillations: bichloride of mercury, phenol, medicated oils like gomonol, and methylene blue all have their advocates. If ulcerations exist, treatment with fulguration or caustics is often useful. Urinary sumptoms may be prolonged because of the persistence of a secondary infection or the co-existence of lesions of the ureter or prostate and seminal vesicles. When all of these resources have been exhausted, distressing symptoms may still remain. To this unhappy and pitiable group of patients with frequent and painful urination, life is scarcely worth while. They will obtain relief only through some operative procedure aimed at sidetracking the urine and thus putting the bladder at rest. Suprapubic drainage gives temporary relief only, if at all. Nephrostomy seems justifiable only as a preliminary measure to improve the kidney function and reduce the degree of hydronephrosis preliminary to diversion of the urinary stream by some operation on the ureter. Ultimately, implantation of the ureter to the skin or in the intestinal tract seem to offer the only possibilities of relief.

The decision between these two courses depends first on a comparison of the two operations for diverting the urinary stream, as done for any and many reasons; and secondly, on a consideration of what is best for tuberculosis cases in general and for a specific patient in particular.

The skin operation was decidedly the less risky until recent years when rapid strides have been made in improving the technique of anastomosis of the ureter and the bowel. Supported by much experimental work, clinicians have been able to report excellent results. Should the immediate mortality from this operation be shown in the future to be but little greater than that to be expected from implantation of the ureter in the skin, and the expectancy of life as favorable (and these are possibilities), there is no question that the bowel operation will become the one of choice in most cases. The absence of urinous odors about the individual and of an apparatus needing continuous care, together with the greater comfort and greater freedom of action following the bowel operation, are the chief arguments coming to mind.

At present, in the hands of most surgeons, anastomosis of the ureter to the skin has less immediate mortality than anastomosis to the bowel, and is undoubtedly the method of choice in debilitated individuals. Papin[2] reported that a search of the literature to 1925 showed 50 per cent mortality for all ureteral transplants to the large bowel. Yet skilled surgeons with large opportunities for this type of work, such as Coffey, C. H. Mayo and Lower, have shown what may be expected of the newer methods of ureterointestinal anastomosis. Coffey's report[3] of 20 consecutive operative cases, many with double implants at one operation, with only one hospital death, is particularly encouraging.

The late results of transplantation of the ureter to either skin or bowel seem to be largely dependent on the presence or absence of obstruction and infection. Both may be encountered after either type of operation. Obstruction following anasto-

mosis to the skin is controllable by the use of a permanent ureteral catheter or regular dilatation or incision, whereas obstruction at the end of a ureter implanted in the bowel is out of reach, dependence being entirely on the development and execution of good technique. One naturally supposes that renal infection would more frequently follow implantation of the ureter in the bacteria-infected gut than in the relatively clean skin. Yet only experience will answer this question. McKenna[16] has shown an absence of infection and no decrease of function in the kidneys of experimental animals, more than a year after the ureter was transplanted into the bowel by Coffey's method. Also let us not forget the natural history of exstrophy cases,[4] that over 50 per cent of these patients die under ten years and but 30 per cent reach the twentieth year; and in a large percentage of these deaths infection is the cause.

While the length of life following transplantation of the ureter to the skin is presumably as favorable as that following transplantation to the bowel, I have not encountered, in a perusal of recent publications, a patient who had lived more than six years after the skin implantation, at the time of the report. No attempt has been made as yet to follow up this point in the earlier literature. On the other hand, Turner[5] reported patients living up to fifteen years following ureteral transplantations to the bowel after the manner of Stiles (no attempt to construct a mucous membrane valve); and I know of two patients who lived at least seventeen years, one after a Maydl[4] and one after a Bergenhem[6] operation for exstrophy. Ester[19] reported the results of a case, twenty-four years after such operation.

It seems to be generally conceded, and is supported by much experimental work, notably that of Sweet and Stewart,[7] that the lymphatics of the ureter represent the chief route followed by infections from the bowel to the kidney, especially in the early portion of the trip; and operations have been devised to protect the end of the ureter from bowel contamination. It would seem that sealing by mild cautery coagulation of the cut end of the ureter should serve this purpose. But I have not yet tried this technique. Coffey and others have advocated the use of an indwelling ureteral catheter during the early days after operation, believing that fewer kidney infections follow and that temporary obstruction by edema is thereby avoided. The ligature holding the catheter in the ureter probably closes the ureteral lymphatics to infection temporarily, and some sealing of the free end of the ureter left after the sloughing distal to the ligature is caused by the traumatic pressure of the ligature. On general principles, I have not liked this use of catheters in the ureter as the presence of a foreign body in any part of the urinary tract promotes infection. But many operators have followed Coffey's lead in this matter, and the experimental work of Sisk, Wear and O'Brien[18] adds evidence in favor of the catheter. Moreover, I have had no trouble with temporary obstruction after operation, in a small experience. Five ureters have been implanted into the bowel by the Coffey method in four patients, and urine has appeared in the rectum in all cases within twelve or fourteen hours, and an abundant amount expelled in the next twenty-four hours. In only one case was a catheter used in the ureter, and curiously the corresponding kidney was the only one in the series which was tender subsequent to operation. C. H. Mayo[8] reported in February, 1930, that he still used no catheter in doing uretero-intestinal anastomosis, but operates on but one ureter at a time.

As for the results in tuberculosis cases in the recent literature, Rosenkranz[9,10] reported two patients alive and well two and four years after ureteral transplantation in the skin (done subsequent to nephrectomy for tuberculosis); and one that died in two weeks. He felt the latter represented an error of judgment in that

the patient was weak and probably had abscesses in his kidney. Mathé[11] had two similar cases, one traced for seven months. Keyes[12] transplanted a single ureter to the skin in two patients who had previously undergone nephrectomy, and they were comfortable four and five years later; and both ureters in one patient of bilateral renal tuberculosis, known to be living two years later. Papin[13] reported 13 such transplants of ureters in tuberculosis, one apparently well six years later.

Hinman[14] transplanted a ureter to the bowel in four patients subsequent to nephrectomy for tuberculosis. One died four and a half years later from anuria and toxemia due to obstruction by a calculus in the upper ureter; one died a year later from pneumonia; another was living two years and two months after operation; and the fourth died twenty-three days after operation from miliary tuberculosis. Coffey[3] included in his report of November, 1929, two similar patients, living a few months after operation. Kinloch and Drexler[15] published one similar patient living six months after operation. Burnell[20] reported one patient, able to work, with occasional renal pain, one year after operation. Walters and Wright[17] included in a report of operations on single kidneys and ureters, two cases of ureteral transplantation to the bowel subsequent to nephrectomy of the other side for tuberculosis; both of these patients died; they were described as having had "irreparable" disease of the kidneys. Evidently some operations in both groups have been undertaken with misgivings in very sick patients, with the hope of relieving an intolerable condition.

It seems clear that at the present time there is not sufficient evidence available to permit a final conclusion concerning the immediate risks and ultimate prospects of life following the implantation of a single ureter to the skin or in the bowel. But the degree of comfort experienced after operation is certainly in favor of the latter procedure.

My present attitude is that all patients who still have urinary distress after nephrectomy for tuberculosis should have both general and local treatment for a long time before the surgeon is justified in concluding that nature will not afford relief. But when that decision is reached, some type of exclusion of the bladder must be considered. Debilitated persons and those whose remaining kidney is known to be tuberculous, should be offered transplantation of the ureter to the skin of the iliac region. I should not feel justified in transplanting to the bowel a ureter which is discharging tubercle bacilli. Those patients in better general condition whose kidney has fair function and cannot be proved tuberculous, will derive much more comfort and greater satisfaction from uretero-intestinal anastomosis.

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[For Remainder of References see p. 284.]

ABERRANT ENDOMETRIUM*

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WHEN tissue resembling the true endometrium or endosalpinx is found elsewhere than along the lining of the lumen of the uterine cavity or Fallopian tubes it is called aberrant endometrium. The pathological process has been termed endometriosis or adenomyosis and the individual lesions have been named endometriomata, endometrial transplants or implants, hemorrhagic perforating cysts and chocolate cysts of Sampson. The adenomyomata are those tumors that contain smooth muscle in addition to the endometrium-like glands and stroma. They have also been called, when in the Fallopian tube, adenomyosalpingitis, adenomyositis tubae and salpingitis isthmica nodosa.

HISTORY

Adenomyomata of the uterus have been known for a long time. According to Graves[1] our earliest knowledge of endometriosis dates back to 1860 when von Rokitansky first described an adenomyoma as a pathological entity. Shroeder, Herr and Gresskoff, according to Breus and Cullen,[2] were able to collect a total of one hundred cases up to 1884. Two years later von Recklinghausen again described these adenomyomata and suggested that they arose from a rest of the Wolffian body. Cullen[3] was the first definitely to identify endometrial tissue springing from some point outside of the uterus. He reported an adenomyoma of the round ligament in 1896. Two years later, after removing a similar tumor from the round ligament on the opposite side of the same patient, Cullen[4] suggested that the glands might be due to an abnormal embryonic deposit of a portion of Müller's duct. This was suggested, he said, from the striking resemblance of the glands of the adenomyoma to those of the uterine mucosa and from the fact that their stroma resembles that of the uterine mucosa. At this time he referred to a case reported by A. Martin in 1891. The patient was seventy years old and complained of a rapidly growing tumor. The growth sprang from the left round ligament and contained 12 litres of chocolate-colored fluid. There were several small cysts in the pedicle which contained clear fluid. One of these cysts was lined by low cylindrical ciliated epithelium. Quoting from Cullen, "Martin says that in this case the structure and contents corresponded to those of tumors arising from the parovarium."

Shortly after the first report of an adenomyoma originating outside of the uterus, according to Cullen,[4] Pfannenstiel reported adenomyomata in the inguinal region and vagina of a patient, Herff reported two vaginal adenomyomata and Blumer reported an adenomyoma in the inguinal canal.

The first report in the English and American literature of endometrium-like tissue in the ovary was made by Russell[6] in 1899. He refers to a case reported by Burkhard* in 1896. It was not until the third decade of the twentieth century, however, that the frequency of this condition was recognized. In 1917 an article appeared by Emil Novak[9] on hematoma of the ovary, which does not mention aberrant endometrium. While directly preceding this in the same bulletin is an excellent paper on adenomyoma of the rectovaginal septum by Cullen.[14]

Adenomyomata of the umbilicus containing uterine mucosa were first described by Cullen[5] in 1909. In an article on this

* *Virchow's Archiv*, vol. 144.

subject three years later he reported a total of 9 cases.

The first report of a case of adenomyoma of the rectouterine or rectovaginal septum I was able to find in the English or American literature was by Lockyer[7] in 1913. Shortly after this 2 more cases were reported by Cullen.[8]

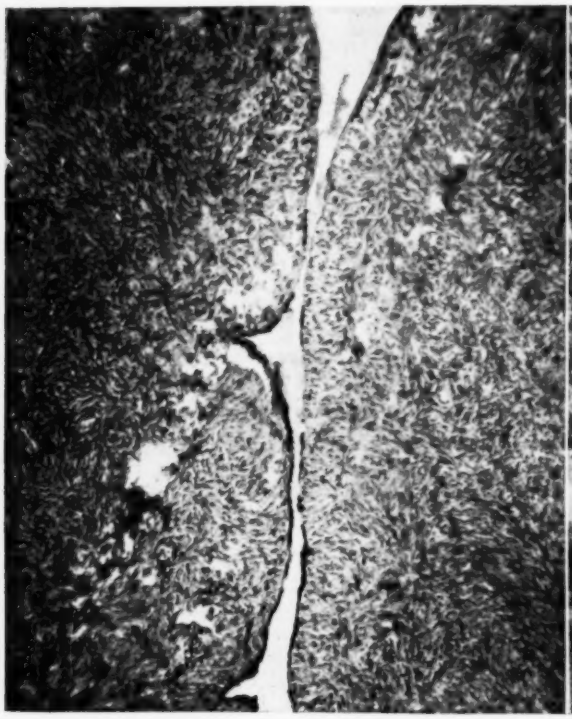

Fig. 1. Invagination and metaplasia of germinal epithelium covering ovary. Note variation in height of epithelium. Surface of ovary is above.

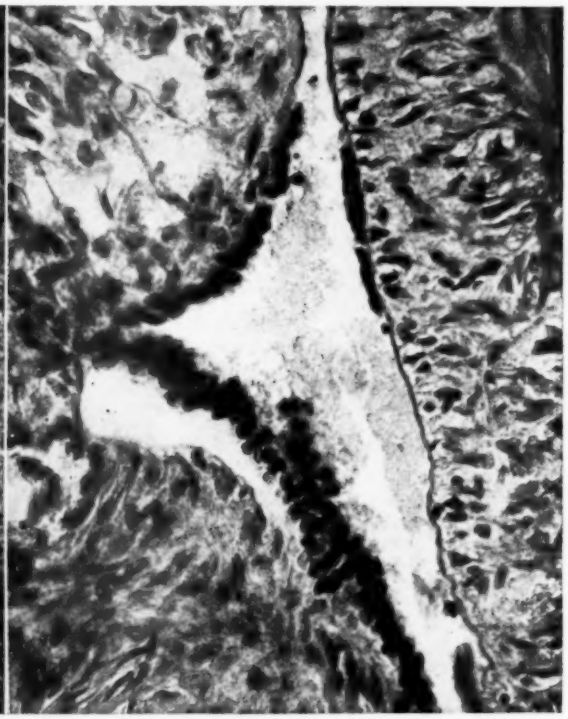

Fig. 2. Greater magnification of an area shown in Figure 1. Note variation in height of epithelium.

During 1919–1920 aberrant endometrium, excluding uterine adenomyomata, began to be recognized as a clinical entity and not as just a pathological curiosity. In 1919 Norris[10] reported finding endometrium in the ovary. During the same year Casler[11] reported actual menstruation from uterine endometrium in an ovary. A panhysterectomy and unilateral salpingectomy had been done previously for adenomyomata of the uterus. Drainage was made through the vagina. Subsequent menstruation occurred through the sinus in the vagina caused by the drainage tube. A second operation was done and typical uterine endometrium was found to have developed in the remaining ovary. During 1919–1920 Cullen[12] published several papers on the distribution of adenomyomata containing uterine mucosa. He had found aberrant endometrium in ten places. Mahle and MacCarty[13] reported from the Mayo Clinic 10 cases of adenomyomata arising outside of the uterus. It is interesting to note the distribution of these tumors. They were found in the unbilicus (1), abdominal wall (2), sigmoid colon (1), groin (2), and rectovaginal septum (4). During this period the thousands of cases in which aberrant endometrium occurred in the ovaries evidently escaped unrecognized.

In 1921 Sampson published the first of a large series of very interesting and instructive articles on aberrant endometrium. I believe one is justified in saying that Sampson is chiefly responsible for the recognition of endometriosis as a definite clinical entity. He has also presented an entirely new theory[16] for the origin of aberrant endometrium. According

to his theory some of the mucosa from the lining of the uterus or Fallopian tube becomes detached and travels out through the Fallopian tubes to be deposited on the surface of an organ in the peritoneal cavity. Here, he believes, it becomes implanted and grows, infiltrating its host. Before the birth of this theory the aberrant endometrium was believed to have arisen from remnants of either the Wolffian or Müllerian duct, or from a metaplasia of the pelvic peritoneum. The implantation theory of Sampson became very popular from the time of its introduction and has remained so up to the present. Until Novak[15] voiced his objection in 1926 the implantation theory stood more or less generally accepted for the origin of at least some of the aberrant endometrium. Novak believes that the aberrant endometrial tissue results from a transformation of the germinal epithelium or pelvic peritoneum.

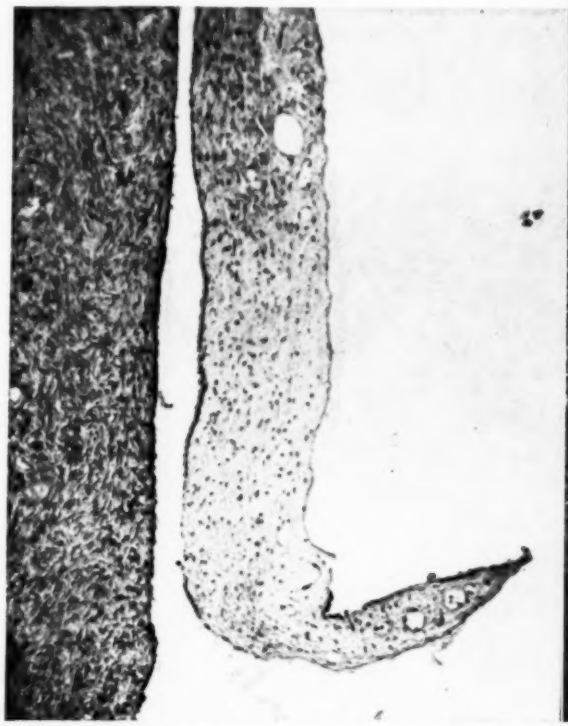

Fig. 3. Another area from same ovary as shown in Figure 1. Invagination of epithelium is again occurring but parallel to surface of ovary instead of perpendicular to it. A variation in height of epithelium can also be seen in this picture.

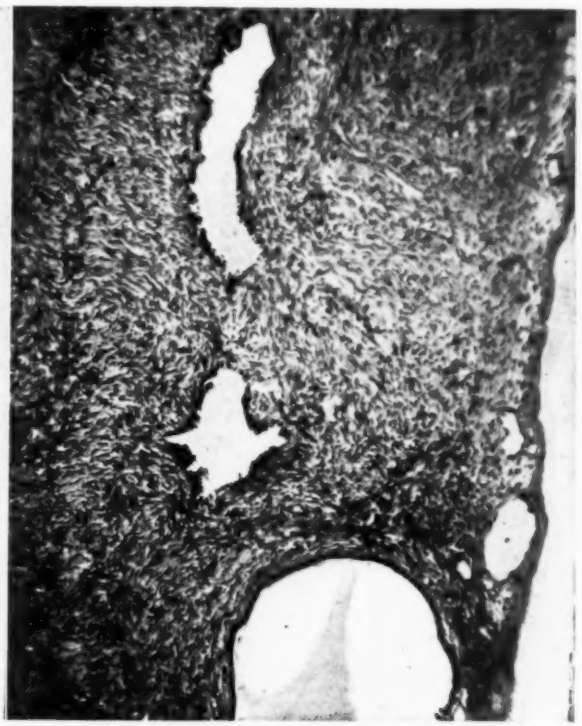

Fig. 4. Another area of same ovary shown in Figures 1 and 3. Three small "endometrial" cysts are lined principally with high columnar ciliated epithelium. They represent a more advanced stage in metaplasia of germinal epithelium into aberrant endometrium.

INCIDENCE

There are a good many references to aberrant endometrium in the medical journals today, but it is not yet universally recognized nor is the true incidence appreciated. The general surgeon in particular is overlooking this not infrequent condition. So much has been written on the histogenesis of the misplaced endometrium that its incidence has not been sufficiently emphasized. Many excellent men admit that they are finding large numbers of these cases which they have previously overlooked.

Before a discussion of the real incidence of aberrant endometrium it is important to bear in mind that in the great majority of patients the only lesions are small symptomless cysts which are readily overlooked unless an effort is made to find them. They are most frequently situated in the ovary or somewhere on the pelvic peritoneum. These cysts vary in size from

those that can only be seen by the microscope to those about 1 cm. in diameter. Since in so many cases the cysts are first discovered at the routine microscopic examination of the tissue removed, there must be an enormous number that are missed entirely and would only be found by serial sections of the tissue removed. The number of patients in whom the aberrant endometrium is fairly extensive and probably producing symptoms is small as compared to the large number of patients with the small symptomless lesions. For these reasons the incidence reported by different men depends on the interest manifested in this condition and the efforts made to find these lesions. Sampson reports the greatest incidence because he looks for endometriosis in every patient. Sampson found 159 cases of endometriosis in 664 abdominal operations for pelvic disease in three years.

An attempt was made by the author to collect all of the cases of aberrant endometrium from the records of Touro Infirmary from January, 1927 to January, 1931. During this time there were approximately 1100 operations for pelvic disease and aberrant endometrium was found in 135 patients. I do not think that these were all of the patients that had aberrant endometrium because many of the lesions were first found by microscopical examination of the tissue removed at operation. The sections were made at random through this tissue and many areas of aberrant endometrium must have been missed. The condition was undoubtedly not recognized many times at operation when no tissue was removed.

It is interesting to compare the incidence of this condition to the occurrence of other pelvic disease. It was estimated that 35 patients, excluding the ade-

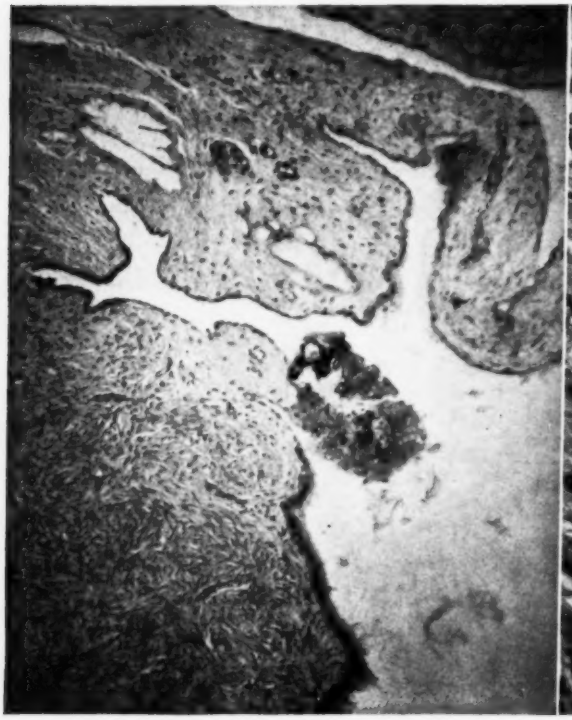

FIG. 5. Section of an ovary showing a metaplasia of germinal epithelium. Epithelium below covering surface of ovary can be seen to be high columnar. Note change to cuboidal and flat and again to a higher type in depth of invagination. Also notice inflammatory exudate on surface of ovary. Some believe that this might be acting as stimulus causing metaplasia.

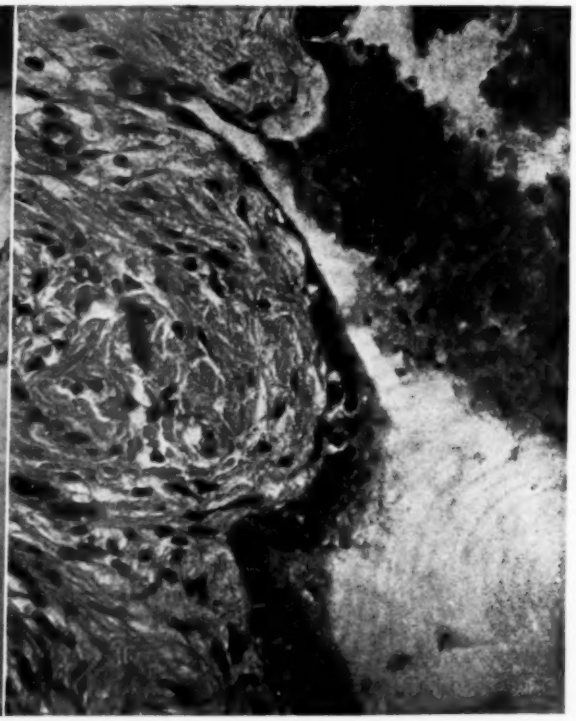

FIG. 6. Greater magnification of an area shown in Figure 5. Histology of epithelium can be plainly seen in this photomicrograph.

nomyoma group, had aberrant endometrium with adhesions sufficiently extensive to have produced at least part of the

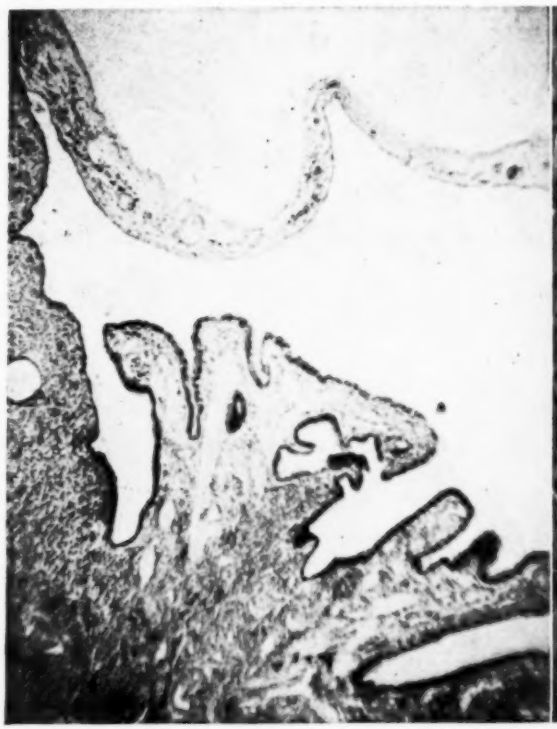

Fig. 7. "Endometrial cyst" on surface of an ovary. This represents a still more advanced step in metaplasia of germinal epithelium of ovary. On right and below, epithelium and stroma is such as to resemble tubal endosalpinx. On left and above, cyst is lined by flat epithelium.

Fig. 8. Area of transition from low to higher epithelium in "endometrial cyst"; greater magnification of area of cyst shown in Figure 7.

patients' symptoms. Some other common pelvic diseases occurring in Touro Infirmary during the time this series was taken are as follows:

Uterine fibroids	497
Chronic salpingitis	280
Uterine displacements	202
Cystadenomata of ovary	40

Thus it can be seen that in this series, while aberrant endometrium is not as frequent as some other common pathological conditions, it is not to be considered a rarity.

HISTOGENESIS

The theories concerning the origin of aberrant endometrium have been numerous. In the earlier literature two were outstanding, viz.: from a displacement of a portion of the Wolffian duct or from a part of Müller's duct. In 1896 von Recklinghausen reviewed the literature and with the report of many new cases came to the conclusion that adenomyomata of the uterus were derivatives of the Wolffian duct. He thought he could recognize a close similarity between the glandular part of the adenomyomata and the elements of the Wolffian duct. In many places the glands were arranged in such a manner as to resemble glomeruli and von Recklinghausen called these areas pseudo-glomeruli.

Russell[6] believed the epithelium he found in the ovary, which was really aberrant endometrium, was due to "an anomalous point of development of portions of the Müllerian duct in the germinal epithelium." Cullen[4] was of the opinion that the adenomyoma he found in the round ligament in 1898 was due to an abnormal embryonic deposit of a portion of Müller's duct.

In 1908 Cullen[2] clearly demonstrated the invasive qualities of endometrium and demonstrated the true origin of uterine adenomyomata. In 50 uncomplicated cases of adenomyomata of the uterus he was able to demonstrate in every instance a definite connection between the glandular structure in the musculature and the lining of the uterine cavity. This was done by making a large number of sections through each uterus.

FIG. 9. Area of rather typical uterine type of aberrant endometrium found on Fallopian tube of same patient from which "endometrial cyst" shown in Figure 7 was taken. Glands and stroma in this area closely resemble uterine endometrium while in upper left hand corner musculature of tube can be seen.

FIG. 10. Section through appendix demonstrating aberrant endometrium.

At the present time there are two popular theories for the origin of aberrant endometrium within the pelvis, exclusive of the adenomyomata of the uterus. These theories are the implantation and the coelomic. Sampson is the originator of the implantation theory. He believes that bits of the uterine endometrium set free at the time of a normal menstruation or following a curettage make their way through the Fallopian tube and fall free into the pelvic cavity. Sampson believes the endometrium becomes implanted where it is deposited and begins growing and infiltrating. This more often occurs on the ovaries, he believes, due to the proximity of the fimbriated extremities of the tubes to the ovaries. He says that regurgitation through the tubes is often assisted by conditions tending to cause an obstruction to the normal menstrual flow. The incidence of endometriosis has been reported greater in patients with fibroids, pelvic infections and displacements of the uterus, all of which might cause an obstruction to the normal exit of the menstrual blood. Sampson believes that the endometrial transplants menstruate and sometimes form cysts which contain the products of menstruation. Sometimes, he has shown, these cysts rupture and their contents are spread over the peritoneal cavity. The endometrium in these cysts becomes implanted in fresh places on the peritoneal surface and forms daughter cysts. He says: "It seems to me that the condition

found in many of these specimens is analogous to the implantation of ovarian papilloma or cancer on the peritoneal surface of the pelvis from the rupture of an ovarian tumor containing these growths."

Fig. 11. Aberrant endometrium in appendix. Higher magnification of area shown in Figure 10. Endometrial glands and stroma are buried in musculature of appendix.

Fig. 12. Section through isthmic portion of Fallopian tube demonstrating aberrant endometrium on its surface and deep in its wall.

Sampson's implantation theory has probably been the most popular of the several theories since its introduction because, I believe, it is the simplest and easiest to understand. I do not think its popularity necessarily implies that it is the true explanation for the aberrant endometrium. Sampson[17] summarizes the facts in support of his beliefs:

1. They are of frequent occurrence (64 instances in 296 abdominal operations for pelvic conditions in one year).

2. They apparently develop during the menstrual life of women and are most frequently found in patients between thirty years of age and the menopause.

3. The histological structure of the endometrial elements in these implants, including the incidence of ciliated epithelium, is identical with that found in the invasion of the uterine wall by the mucosa lining its cavity.

4. The tubes are usually patent and even though occluded the implantation could have occurred before the tubes became closed.

5. The uterus in these patients is often retroflexed, or contains leiomyomata and polyps, conditions which might sometimes favor a backflow of menstrual blood through the tubes.

6. Occasionally blood may be observed escaping from the fimbriated ends of the tubes of patients operated upon during menstruation. The microscopic examination of this blood may show epithelial cells. The histological study of sections of the tubes may also show epithelium and bits of endometrial stroma lying free in the lumen of the tube.

7. As the study of ectopic endometrial tissue in the pelvis demonstrates that implants may sometimes arise from this, it is natural to assume an implantation origin for the former, if a source could be found. Menstrual blood escaping through the tubes indicates a source.

8. They are often found in different stages of development in the same individual, thus

suggesting repeated implantations from the original source or from other implants.

9. The early implants are found on structures in the pelvis which would naturally be reached by blood escaping through the tubes and they are most frequent on the structures in close anatomical relation with the fimbriated ends of the tubes. They may be present only on the peritoneum or only on the ovaries, but are usually found on both. Their distribution is often bilateral, as occurs in pelvic inflammatory lesions of tubal origin.

10. Similar growths have been observed in the scar of the abdominal incision of patients in whom the uterine cavity has been opened, thus affording the opportunity of implanting bits of uterine mucosa in the tissues of the abdominal incision.

11. Jacobson has reproduced lesions similar in many respects by the autotransplantation of bits of the uterine mucosa of the rabbit into the tissues of the pelvis.

The chief opponent of this theory is Novak,[15] who makes out, as Maes[19] says, "an excellent case for the opposition." In the histologic study of many hundreds of Fallopian tubes with particular reference to their contents, Novak found only seven which contained particles of uterine mucosa lying free in the lumen. None of the women from whom these seven tubes were removed were menstruating, most of them being many days from this period, and in no instance did the endometrium in the tubes have the appearance of endometrium thrown off at menstruation. In 5 of the 7 cases the particles of the free endometrium were so large that it would seem almost impossible for them ever to have entered the tiny uterine orifice of the tube. Novak believes that the tissue was moving towards the uterus rather than away from it, endometrial tissue being found in the ovary in 2 of these patients. In several other cases only a very small amount of

Fig. 13. Aberrant endometrium in Fallopian tube. Higher magnification of an area shown in Figure 12: Notice endometrium-like glands are surrounded by musculature of tube.

Fig. 14. Aberrant endometrium in tube. Greater magnification of an endometrial gland from an area of Figure 13. Notice lack of any "endometrial" stroma and the cilia on epithelial cells. Glands are resting on musculature of tube.

ovarian tissue was removed and subjected to examination.

Novak does not believe that blood

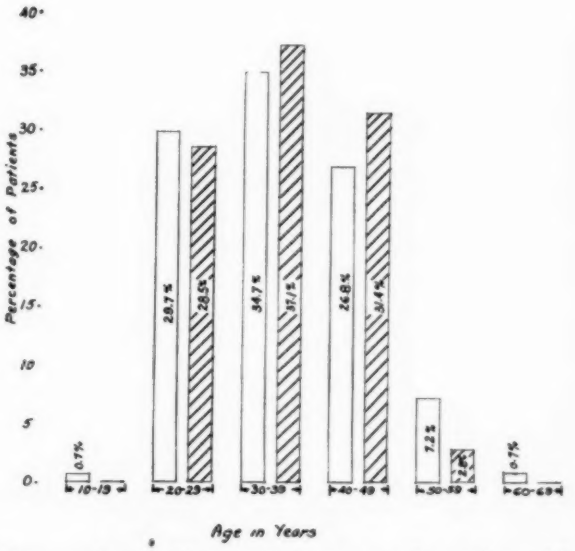

Fig. 15. Age incidence of aberrant endometrium. All cases, plain; severe cases, shaded.

regurgitates through the tubes during menstruation. In 13 patients operated upon by himself during menstruation, he has not seen regurgitation in one. He says that histologic examinations of tubes removed during menstruation characteristically show no blood in their lumen. He calls attention to the fact that no blood has been found in the pelves of thousands of women operated upon by thousands of surgeons immediately after menstruation, although it would hardly have had a chance to be absorbed during this time. He also calls attention to the absence of any frequent peritoneal reaction, as after a ruptured tubal pregnancy, that we would expect to get with the hemorrhage into the cavity from the rupture of a chocolate cyst or spilling of blood regurgitated through the tube.

Novak also questions the retrograde transportation of endometrial tissue into the tube. He thinks the ciliary current to be more important than muscular peristalsis in the passage of the ovum from above downward. He believes antiperistalsis is rare and present only in conditions of overdistention of the tube as proved by recent investigation. He calls attention to the fact that the uterine portion of

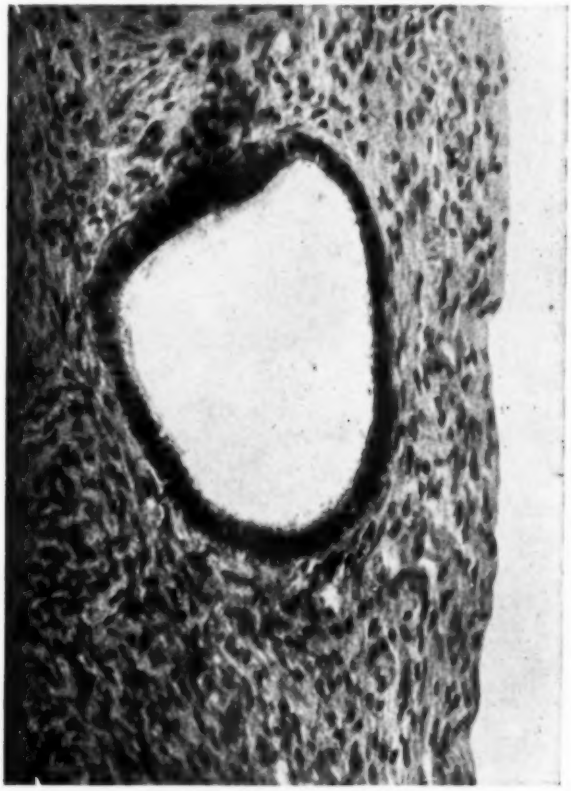

Fig. 16. "Endometrial cyst" found on surface of ovary in youngest patient.

the tube measures only 0.5 to 1 mm. in diameter so that it would really seem almost incredible that this opening could admit such large pieces of endometrial tissues as are seen in his specimen. He says that if a piece of endometrial tissue made its way through the uterine os of the tube it would still have an almost impassable passage through the very fine lumen of the interstitial portion of the tube; the latter passing in a gently curved or sinuous fashion through the thick musculature of the uterus.

In this connection Sampson[20] says:

I am convinced that the manipulation of the uterus and tubes, incident to pelvic operations, may at times detach uterine and tubal epithelium and cause it to be transferred not only to the abdominal wound, but also to the tissues of the pelvis. This is particularly true

for endometrial tissue if the abdominal operation has been preceded by a curettage. In such instances I have frequently observed blood escaping through the fimbriated ends of the tubes during the abdominal operation. I have also seen instances of peritoneal endometriosis which apparently had resulted from a previous operation.

Fig. 17. Endometrial gland and stroma buried deep in musculature of uterus in oldest patient in this series.

Fig. 18. Aberrant endometrium on peritoneal surface of Fallopian tube. This tissue was removed from patient during course of normal pregnancy; Case III.

Blood has been reported at the fimbriated ends of the Fallopian tubes in patients operated upon during the normal menstrual periods by Danforth,[21] Curtis[21] and others.

Blood has been reported at the fimbriated ends of the tubes following curettage by Goodall,[21] Heaney,[21] and others.

Novak questions the ability of the endometrium cast off at menstruation to grow on the ovary or peritoneum. He says that the tissue thrown off is degenerating and doubts that it will have sufficient vitality, after traversing the tube, to grow where it falls. Since it takes several days for the ovum to pass from the ovary to the uterus it must take longer for tissue to pass in the retrograde direction.

Novak further objects to the theory because:

1. The endometrium is not infrequently found chiefly and perhaps exclusively, in parts of the pelvis or elsewhere, where implantation from the tube would not be easy;
2. It is often present in extremely small amounts, in spite of the supposed monthly regurgitation and the proliferative tendency of the tissue;
3. It is characteristically confined to the pelvis, even when extensive endometriosis is present, unlike cancer which can implant itself over the entire abdominal cavity.

The coelomic theory has been known in one form or another for a long time. Novak[15] speaks of it as a concept rather than a theory. He describes it very clearly. He says:

It is possible, as some have suggested, that the occurrence of ectopic endometrium at

various points in the pelvis is due to the presence of celomic rests in these regions. But it is just as possible that, aside from the develop further into an endometrial or tubal epithelial cell. The same statement may be made of the pelvic peritoneum. What the

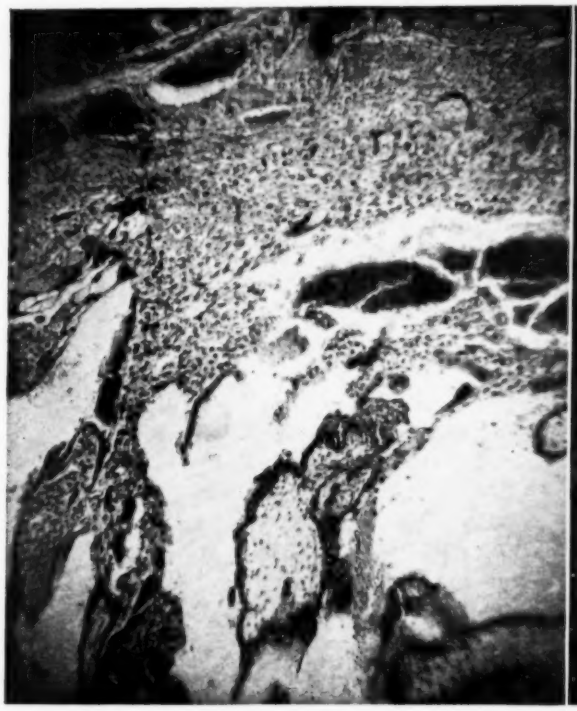

Fig. 19. Section of Fallopian tube showing villi in patient with an extra-uterine pregnancy.

Fig. 20. "Endometrial cyst" on ovary in same patient from which tissue shown in Figure 19 was taken. No definite "endometrial" stroma about this cyst.

"rest" theory, the normal germinal or other epithelium of the ovary, or the normal pelvic peritoneum, may under the proper combination of endocrine and other conditions, be quickened to various differentiation phases abnormal for the tissue concerned.

This is no mere speculation, for embryologists, on the basis of careful observations, accept the view that there is a definite and intimate relation between all of the epithelial tissues arising from any one of the embryonic layers. Each one of the original embryonic layers possesses developmental potentialities, which, for various organs, are limited at various stages as a result of certain physical or chemical factors, either local or general. It thus is evident that the potency of the cells is not used up, so that if, in later life, the same conditions arise which are responsible for the original development of the cells in question, they may be activated into new growth. For example, a germinal epithelial cell retains a considerable degree of unused developmental potency, and with the proper activation, can activating conditions are we cannot say, except that they are almost certainly of endocrine nature. As already stated, these views are not merely speculative, for, as Fischel has emphasized, they have considerable support from embryologic studies.

Applying this conception to the subject matter of this paper, one can readily understand why such an intimate relationship exists between the cells of the pelvic peritoneum, the germinal epithelium, the tubal mucosa, and the endometrium, for they are all descendants of a common mother tissue, the celomic epithelium of the urogenital folds. In this sense the endometrium and endosalpinx are to be looked upon as merely a modified peritoneum, or a modified germinal epithelium, so that it is not so startling to think that either peritoneum or germinal epithelium, plus the necessary but as yet unknown biologic activating stimulus, may give rise to more or less typical Müllerian mucosa . . .

A consideration of possible importance lies in the fact that the activating hormones are

probably found in the ovary itself, and that the frequency of germinal epithelial metaplasia may perhaps be due to its proximity to the source of supply of the hormone—that perhaps there is a greater intensiveness of endocrine action in the ovary itself than in more distant tissues.

Novak thinks he is able to identify many of the stages of differentiation from the germinal epithelium to the uterine endometrium. He has found areas of epithelium growing in the ovary which closely resemble the endometrium of the fetal or infantile uterus. He believes the reason all of the aberrant endometrium does not menstruate is that some of it has not differentiated sufficiently to be excited by the hormone that causes the cycle in the uterine endometrium. Sampson believes that menstruation occurs in the cysts and the blood is reabsorbed. In support of this view he has been able to demonstrate blood pigment in the tissues around the cysts. We know definitely that all aberrant endometrium does not react to pregnancy as does the uterine endometrium, Sampson reported post-salpingectomy endometriosis in 3 patients that were operated upon for tubal pregnancies. In only one of these was there a decidual reaction in the misplaced endometrium. However, in the other 2 patients the aberrant endometrium probably arose from the tubal endosalpinx. In the series reported by the author tissue resembling aberrant endometrium was found associated with pregnancy in 2 patients. In neither was there a decidual reaction in the misplaced endometrium-like tissue. The absence of a decidual reaction in aberrant endometrium may be explained in the same manner that the failure to menstruate is accounted for, i.e. the aberrant endometrium has not sufficiently differentiated to react to the hormone which causes the uterine endometrium to undergo a decidual reaction.

Novak has also been able to demonstrate tissues closely resembling the uterine and tubal endometrium growing next to each other and being continuous with one another. This is additional evidence in support of the metaplasia theory, he believes. He presents an excellent photomicrograph of such an area in one of his articles.[15] In the histological study of aberrant endometrium one is frequently able to find an area of endometrial like tissue the epithelium of which can be seen to grade off into the germinal epithelium covering the ovary. Russell[6] demonstrated such an area in his original report and such a condition is seen in Figure 6.

It seems very likely that both theories are correct and the aberrant endometrium has its origin in both manners.

PATHOLOGY

Aberrant endometrium has been reported in a large number of places. It has been described on all parts of the peritoneum in the pelvis. It has been described frequently on the large and small bowel as intestinal adenomata or adenomyomata. It has been frequently found on the appendix. Aberrant endometrium has not infrequently been reported in the groin, labia majora, vagina, umbilicus, and abdominal wall. Aberrant endometrium has been reported in the sac of an inguinal hernia.[25] With one exception it has always been found below the level of the umbilicus. Hosoi and Meeker[22] reported a case of endometrial carcinoma of the mid-portion of the transverse colon. This portion of the intestine might easily have been much lower in the abdomen when the patient was in the erect position.

The aberrant endometrium sometimes infiltrates the organ on whose surface it is located and is found buried deep in this organ. Thus it not infrequently involves the bowel, especially the sigmoid colon and rectum, to such an extent that it produces an obstruction. It has been found to infiltrate the bladder sufficiently to be recognized at cystoscopy. Hosoi and Meeker[22] reported finding 10 cases of

endometriosis of the bladder wall reported in the literature.

Aberrant endometrium is not infrequently found in scars from abdominal operations, usually following operations on the female genital organs, but several cases have been reported following simple appendectomies. Hosoi and Meeker[22] were able to find 87 cases of endometriosis in laparotomy scars reported in the literature.

Hosoi and Meeker[22] were also able to find epithelial inclusions of endometrial type in lymph glands as reported by several observers.

Adenomyomata of the rectouterine and rectovaginal septum are not infrequently found. Adenomyomata of the uterus are too well known and their incidence too well appreciated to be considered here.

The histological picture of the lesions described as aberrant endometrium varies from single cysts, too small to be seen by the naked eye, lined with cuboidal or columnar ciliated epithelium and surrounded by little or no stroma, to tissue histologically identical with tubal or uterine endometrium. Any gradation from one extreme to the other can be found. As Novak has shown, areas can be found which resemble the fetal or infantile endometrium. Areas can be found where rather typical uterine endometrium adjoins and is continuous with rather typical endosalpinx.

The cases of aberrant endometrium in the series reported by the author were classified as follows:

	Cases	Per Cent
Total number of cases	135	
Adenomyomata of uterus	21	15
Peritoneal endometriosis	114	85
Aberrant endometrium fairly extensive with adhesions sufficient to produce symptoms	35	26
Aberrant endometrium less extensive with few or no adhesions	67	49
Aberrant endometrium clinically not found microscopically	11	8

Most of the lesions in the last group were small superficial cysts on the ovary or pelvic peritoneum which were wiped away at the time of operation. All of these patients had more than one lesion of aberrant endometrium and the diagnosis was only accepted when the patients were being treated by men who had a high percentage of correct diagnoses for the entire series.

The distribution of aberrant endometrium in the series reported by the author was as follows:

	Cases
Ovary	99
Tubes	20
Adenomyomata of uterus	21
Anterior or posterior surface of uterus and broad ligament	8
Rectum and sigmoid	7
Cul-de-sac	5
Appendix	4
Cecum	2
Ruptured chocolate cysts	3

It has been the general observation that aberrant endometrium occurs most frequently on the ovary. Sampson says this is because of its close proximity to the fimbriated extremity of the tube. Novak says that it might be because the hormone which is the cause of the epithelial metaplasia has its home in the ovary itself.

The distribution of the aberrant endometrium reported by King[23] was as follows:

	Cases
Rectovaginal space	52
Petitoneum	26
Ovary	23
Uterus	17
Tubes	4

In reviewing the routine microscopical sections of the tissue removed at operation I was impressed with the frequency with which a diagnosis was made first by the pathologist. It was evident that many of the lesions were not being recognized by the surgeons at the time of operation. An examination of the records from this angle revealed this interesting information:

	Surgical Services	Gyneco-logical Services
Total cases	43	89
Cases recognized at operation	1	52
Percentage of diagnosis	2	58

That the general surgeon is overlooking aberrant endometrium is well shown in this series for only one case out of almost 50 was recognized at the time of operation.

To recapitulate, it is impossible to recognize every case grossly or at operation because the endometrium is sometimes so small that it can only be seen by the microscope. This is illustrated by the series of Dr. C. Jeff Miller who was kind enough to let me review his cases. Out of 57 cases the aberrant endometrium was so small as to be found by the pathologist in 11 instances. During these four years Dr. Miller had recognized 46 cases. So we might say in 19 per cent of this series the lesions are so small that they cannot be recognized grossly. I do not think Dr. Miller has overlooked any lesions large enough to be seen readily because he has been particularly interested in this subject for several years and has been watching for this form of pathology.

The relation of other pelvic diseases to aberrant endometrium has been frequently emphasized. Several authors thought they were able definitely to correlate a relationship between aberrant endometrium and uterine fibroids, malpositions of the uterus or chronic pelvic infections. It was and is believed that these diseases in the pelvis are in part responsible for the aberrant endometrium by obstructing the normal exit of the menstrual flow and causing the blood and desquamated epithelium to back up into the Fallopian tubes and into the peritoneal cavity. On the other hand there are some who believe that the inflammation, *per se*, causes an endometrial metaplasia. Associated pelvic conditions were found in this series as follows:

	Cases	Per Cent
Myoma uteri	62	46
Uncomplicated with exceptions of adhesions in pelvis	43	
Pelvic inflammatory diseases	19	
Including pus tubes	2	
Displacements of the uterus	12	8
Pelvic inflammatory diseases not associated with myoma uteri	32	
Total pelvic inflammatory diseases	51	37
Only adhesions in the pelvis besides aberrant endometrium	15	11
Other cysts in the ovary	54	

Associated pelvic conditions reported by other men are as follows:

	Keene-Kimbrough Per Cent	King Per Cent	Smith Per Cent
Myoma-uteri	55.4	22	41.6
Chronic salpingitis	20	39.7*	
Adherent retroverted uterus	14.5	21	25.8

* Evidence of some inflammation in the pelvis.

SYMPTOMATOLOGY

After reviewing the case histories of the patients in this series the author has come to the conclusion that there are no constant characteristic signs or symptoms of aberrant endometrium. Most of the symptoms given by patients coming to operation are produced by some associated pathological condition. The symptomatology may be classified as follows:

1. *Age Incidence.* Aberrant endometrium is believed to develop during the menstrual life of women and Sampson says endometriosis is most frequently found in patients between thirty years of age and the menopause. In the series reported by the author the youngest patient was sixteen years old. The lesion in this patient, however, cannot positively be called aberrant endometrium. The diagnosis was made on the basis of a single cyst lined with cuboidal ciliated

epithelium and not surrounded by any characteristic stroma. A photomicrograph of this lesion is shown in Figure 15. The oldest patient was sixty-one years old and had a rather diffuse adenomyoma of the uterus. King[23] reported finding an adenomyoma in the uterus of a patient sixty-four years old. The respective ages of the patients in this series are shown in Figure 15. The age incidence by decades reported by Keene and Kimbrough[26] is as follows: third decade, 18.6 per cent; fourth, 49.1 per cent; fifth, 25.4 per cent; and sixth, 6.8 per cent.

2. *Sterility.* The importance of sterility as a symptom in these patients has been emphasized. Keene and Kimbrough[26] reported 40.9 per cent of their patients were sterile; Smith 20.6 per cent; and Shirer 84.2 per cent. In the present series 84 per cent were married; 30 per cent of these were sterile. One patient bore twelve children. It must be remembered however, that in many of these patients the aberrant endometrium was considered to be too small to produce symptoms. If only the patients with rather marked endometriosis were considered the incidence of sterility was practically the same, 29 per cent. It would seem then that the associated pathology, fibroids, pelvic infections, uterine displacements, etc., must play a part in the high incidence of sterility of these patients. Twenty per cent of the patients with marked endometriosis were unmarried.

3. *Irregularities of Menstruation.* The consensus of opinion among writers on the subject is that aberrant endometrium, *per se*, produces no characteristic menstrual irregularity. In the series reported by the author the menstrual disorders complained of by the patients were as follows:

	Cases	Per Cent
Menorrhagia	30	22
Metrorrhagia	15	11
Dysmenorrhea	35	26
Amenorrhea after menopause	4	3
No menstrual disturbance	69	51

If only the patients having rather extensive degrees of aberrant endometrium were considered the menstrual irregularities were as follows:

	Cases	Per Cent
Total	35	
Menorrhagia	11	31
Metrorrhagia	3	8
Dysmenorrhea	11	31
No menstrual disturbance	17	48

I do not believe there is enough difference in the percentages of these groups to say that the more extensive endometriosis could produce certain menstrual irregularities. In a series of endometriomata reported by King the menorrhagia could be explained in 75 per cent of the patients by some associated uterine lesion. Keene and Kimbrough conclude that profuse menstruation is usually a symptom of the complicating lesion rather than of the endometrioma itself.

4. *Dyspareunia.* It is impossible to say what percentage of patients in this series presented this symptom, because they were not questioned routinely on this point. There were several patients, however, who gave this symptom as their chief complaint.

5. *Other Important Symptoms.* In addition to the symptoms already mentioned there were two which were rather prominent among the patients' complaints. These symptoms with their relative incidences were as follows:

	All Cases		Extensive Endometriosis	
	Cases	Per Cent	Cases	Per Cent
Pain and tenderness in lower abdomen not associated with periods	38	28	11	31
Leucorrhea	33	24	6	17

Probably the most important individual symptom, when it does occur, is pain

and tenderness over the site of the growths during the menstrual period. This is particularly significant if it can be definitely differentiated from uterine cramps. For instance if the pain and tenderness occurs during menstruation in the scar of a former laparotomy incision or in a nodule in the groin or labia it is very significant. Pain and tenderness do not occur, however, at the menstrual period in all cases of aberrant endometrium. The conclusion I have drawn from the review of the case histories in this series and from the stories of the comparatively few patients I have seen myself is that pain and tenderness at the site of the aberrant endometrium is rather uncommon. Novak has shown, as was said before, that some of the aberrant endometrium resembles the fetal or infantile types and only that which has become sufficiently differentiated reacts to the hormone producing menstruation. Certainly it would not seem probable that the tissues resembling the tubal endosalpinx would menstruate as would the uterine endometrium. In the majority of cases the tissues removed during the menstrual and premenstrual periods have no similarity to the stage of the menstrual cycle found in the uterine endometrium as can be seen from the uterine scrapings. In fact I have not been able to find aberrant endometrium having the appearance of the premenstrual and menstruating uterine endometrium. I do not mean to imply that all aberrant endometrium does not menstruate. I only mean to emphasize that menstruation would seem to be the exception and not the rule. Therefore the symptoms of pain and tenderness over the site of aberrant endometrium, arising from overdistention of the cysts, is not common, but when it does occur it is very significant.

REPORT OF INDIVIDUAL CASES

In this series there are several patients warranting especial attention.

Case I. The youngest patient was sixteen years old. Miss S. B., a white female, was admitted to the hospital with a diagnosis of chronic appendicitis. Her menstrual history was normal. An appendectomy was done and on examination of the pelvis one ovary was found to contain many small cysts. This ovary was resected and the microscopic examination of the tissue removed demonstrated the presence of aberrant endometrium. (See Fig. 16.)

Case II. The oldest patient in this group was sixty-one years old. Mrs. K. J., a white female, had passed the menopause several years previously. Shortly before admission she began to pass clots of blood. Examination revealed multiple fibroids. A supravaginal hysterectomy was done. The uterine endometrium was atrophic and endometrium was found throughout the wall of the uterus. A diagnosis of adenomyoma was made. (See Fig. 17.)

Case III. One patient was operated upon during a normal pregnancy. Mrs. J. S., a white female, forty-two years old, was married. She had two normal children. Twelve years previously she was operated upon at which time her uterus was suspended, the right ovary resected and the appendix removed. Six weeks before admission she received a blow in the abdomen and shortly afterwards began to have irregular bleeding. Examination suggested fibroids, a panhysterectomy was done and a normal pregnancy was found as well as aberrant endometrium on the ovaries. (See Fig. 18.)

Case IV. Endometriosis was discovered in one patient operated upon for an ectopic pregnancy. Mrs. H. B., a white married female, twenty-five years old, believing herself pregnant attempted an instrumental abortion. She was admitted to the hospital two days following the attempt. At this time she had no discharge nor was she suffering pain. On vaginal examination an extra-uterine pregnancy was suspected. After dilatation and curettage the abdomen was opened. The uterus was found bound down in the right side of the pelvis, the right tube enlarged and the middle third ballooned out with a hard nodular mass. The ovary was cystic. A right salpingo-oophorectomy was done. Microscopic studies revealed products of pregnancy in the uterine scrapings; in the ovaries a developing corpus

luteum, follicular cysts and aberrant endometrium; and in the tube an extra-uterine pregnancy. In neither this nor the preceding patient was there any evidence of a decidual reaction in the misplaced endometrium.

Sampson reported 3 cases with post-salpingectomy endometriosis that were operated upon for tubal pregnancies. In two of these there was no evidence of a decidual reaction in the misplaced tubal mucosa of the uterine cornua; nor was it present in the uterine mucosa in either case. In the third patient the endometrium in both cornua showed a marked decidual reaction as did also the mucosa of the uterine cavity.

There were 3 patients in the present series who had ruptured chocolate cysts at the time of operation:

Case v. Miss I. C., a white female, twenty-three years old, was admitted to the hospital with a chief complaint of acute pain in the right lower quadrant of the abdomen. During the day preceding her admission she had suffered from nausea and vomiting, although she had been up and about. At about midnight the pain began in the right lower quadrant of the abdomen and radiated to the left side. Menstruation was normal. There was some tenderness and rigidity over the entire lower abdomen. A vaginal examination was not made, a rectal examination was unsatisfactory. The abdomen was opened with a right rectus incision and the intestines and pelvis were found covered with a chocolate colored non-clotted material which was found to have come from a ruptured chocolate cyst of the left ovary. About one-half of the contents of the sac had been emptied and there was also some bleeding from an implant in the cul-de-sac. There were one or two small superficial implants on the right ovary which were readily wiped off.

Case vi. Miss A. C., a white female, twenty-one years old, was admitted to the hospital with a chief complaint of pain in the right lower quadrant of the abdomen. For several months she had suffered from some mild pain in her lower abdomen. The day before her admission she had a sudden attack of severe pain in the lower abdomen which localized to the right side. Nausea and vomiting followed. Menstruation was entirely normal except for occasional cramps. On examination tenderness and rigidity were present over the lower abdomen. A mass could be identified in the left side of the pelvis. The blood count was 20,000 white corpuscles with 91 per cent polymorphonuclear leucocytes. On opening the abdomen a large amount of thick chocolate-colored fluid escaped. A large ruptured chocolate cyst of the left ovary was found densely adherent to the sigmoid and apparently almost ruptured into the bowel.

Case vii. Miss P. R., a white female, thirty-six years old, was admitted to the hospital with a chief complaint of pain in the upper abdomen. The onset of the pain was three days prior to her admission and the pain had progressively grown worse. It radiated from the upper right abdomen to the lower right quadrant. The patient was nauseated but did not vomit. There was no history of any menstrual disturbance or pelvic discomfort. Her temperature was 100°F., pulse 110 per minute. The blood count was 23,000 white corpuscles with 85 per cent polymorphonuclear leucocytes. Tenderness and rigidity were present over both the regions of the gall bladder and the appendix. On opening the abdomen a prune-juice colored fluid escaped. The gall bladder was distended, its walls thickened and there were a few adhesions but there had been no perforations. The appendix was inflamed from the middle to the tip. Exploration of the pelvis disclosed two small subperitoneal fibroids and a large white flabby mass on the left side, which proved to be an ovarian cyst which had ruptured and discharged its contents into the peritoneal cavity. Probably a quart and a half of this unclotted blood was removed. The collapsed sac which proved to be the left ovary was removed. The patient's condition became steadily worse; she developed an intense jaundice, generalized peritonitis and died three days after her admission.

The case histories of the last three patients are interesting from the standpoint of making a diagnosis. In the first and the last the diagnosis should not have been suspected. In the second preoperative diagnosis of aberrant endometrium would hardly have been justifiable. The pathology found in these last three

patients would tend to support Sampson's implantation theory for the origin of the aberrant endometrium. It is not hard to believe that if the endometrium is sufficiently active to grow and form fairly large cysts, it could become implanted on other parts of the peritoneum in the pelvis after rupture of one of these cysts.

DIAGNOSIS

In the majority of cases it is impossible to make a correct diagnosis of aberrant endometrium in the pelvis before operation. Aberrant endometrium in the pelvis sufficiently extensive to warrant radical treatment would cause enough pathology by the production of adhesions to warrant an exploratory operation. It is very essential that the condition be recognized at the time of operation and the necessary treatment instituted. The occurrence of numerous cysts of varying sizes containing a chocolate-colored fluid and surrounded by many adhesions is characteristic. The small solitary cysts about 1 cm. in diameter containing a dark brown or bluish fluid occurring on the surface of the ovary or any organ or organs in the pelvis are diagnostic.

When the lesions are in the rectovaginal septum the diagnosis is sometimes not so difficult. If several dark blue cysts can be seen beneath the vaginal mucous membrane the condition should be assumed to be aberrant endometrium. The patient might or might not give a history of pain or discomfort associated with the menstrual periods.

If the aberrant endometrium occurs in the round ligament outside of the peritoneal cavity it may be felt as a small mass in the inguinal canal or labia majora. This also may or may not react to menstruation.

Aberrant endometrium in an old laparotomy scar is identified mainly by a history of the scar getting painful and tender during each menstrual period. The patient might report that the scar seems to swell during the periods. I have recently heard of a patient who had a little bloody discharge from a sinus in her scar during each menstruation.

TREATMENT

The treatment of aberrant endometrium should depend on the amount of pathology found. The small superficial cysts should be wiped away with a sponge or burned off with a cautery. If the lesion is a little more extensive it should be excised if possible. If the aberrant endometrium is too extensive to be excised completely, retrogression can be assured by removing the ovaries. This should be done, however, only when the patient's symptoms are rather severe and are apparently due to the aberrant endometrium. Sacrificing both ovaries may give a train of symptoms which would be worse than the symptoms produced by the aberrant endometrium. In view of the large number of very small symptomless lesions as compared to the relatively few larger lesions producing symptoms, it must be assumed that in many instances the pathological condition remains limited for a long while and often never obtains sufficient size to cause any trouble. In view of this fact it would seem criminal to do a bilateral oophorectomy just because some aberrant endometrium was found. Most of the adenomyomata occurring in old laparotomy scars, around the umbilicus and the labia majora or groin can be excised completely.

SUMMARY

1. From the records of Touro Infirmary 135 patients with some form of aberrant endometrium were found in a series of 1200 patients who were operated upon for some pelvic pathology between January, 1927 and January, 1931.

2. Of these 135 cases 15 per cent were adenomyomata of the uterus and 85 per cent were peritoneal endometriomata. The aberrant endometrium in the pelvis was considered to be extensive enough to produce some of the symptoms in 26 per cent of the patients of the entire series.

3. During the time that this series was taken, there were 497 patients with uterine fibroids operated upon; 280 with chronic salpingitis; 202 with uterine displacements;

and 40 with cystadenomata of the ovary.

4. The belief that the condition was not being recognized by the general surgeon was justified. The correct diagnosis was made at the time of operation in 58 per cent of patients on the gynecological services and in only 2 per cent on the general surgical services.

5. It was estimated that in 19 per cent the lesions were so small that they could only be recognized by the microscope.

6. Fibroids were associated with the aberrant endometrial tissue in 46 per cent of the patients. Displacements of the uterus were mentioned in 8 per cent of the cases. Pelvic inflammatory disease was present in 37 per cent.

7. The youngest patient in the series was sixteen years old, the oldest sixty-one. The majority of patients were between twenty and forty-five years of age.

8. Thirty per cent of the patients were sterile. One patient was the mother of twelve children. Twenty per cent of the patients with marked endometriosis were unmarried.

9. Menorrhagia was a symptom in 22 per cent, metrorrhagia in 11 per cent, dysmenorrhea 26 per cent and no menstrual disturbance in 51 per cent. Three per cent were past the menopause. In the group with extensive endometriosis, menorrhagia was a symptom in 31 per cent, metrorrhagia in 8 per cent, dysmenorrhea in 31 per cent and no menstrual disturbance in 48 per cent. The aberrant endometrium was believed to have caused little if any of the menstrual disorders. The symptoms were believed to have been caused principally by the associated pathology.

10. Dyspareunia was present in several.

11. In one instance aberrant endometrium was found in a normal pregnant woman; in one instance it was found in a patient with an extra-uterine pregnancy. In neither of these patients was there a decidual reaction in the aberrant endometrium.

12. Three patients were operated upon and ruptured chocolate cysts found. In none of the three was this suspected before operation.

13. There are no constant characteristic signs or symptoms of aberrant endometrium. In most instances the associated pathology can account for the symptoms and signs. The most important individual symptom is pain and tenderness over the site of the growths during the menstrual period. This, however, is the exception and not the rule.

14. Aberrant endometrium probably has its origin both from the implantation of uterine mucosa regurgitated through the tube and from a metaplasia of the germinal epithelium or pelvic peritoneum.

CONCLUSIONS

Aberrant endometrium is a not infrequent condition which is still escaping general recognition. It sometimes produces marked symptoms of a varied nature depending on the extensiveness of its growth and the organs it affects.

I wish to acknowledge the assistance of Miss Alba Richardson and members of the record room staff of Touro Infirmary in the compilation of the statistics for this paper.

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[For Remainder of References see p. 336.]

ACUTE INTESTINAL OBSTRUCTION DUE TO FETAL PERITONITIS*

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A MALE infant weighing 7 pounds was delivered by version and extraction. The mother was apparently healthy in every way and in particular there was nothing in her history or examination to indicate tuberculosis or lues and at a later date a blood Wassermann test was negative. The baby's condition after delivery and until the tenth day was apparently normal except for a loss in weight a little greater than the average and a temperature that was ½ to 1 degree subnormal most of the time. Breast feeding was used alone until the eighth day when a supplemental feeding was begun. The bowels moved one to five times a day and there was no regurgitation or vomiting during the first ten days. On the tenth day the abdomen was slightly distended, the temperature was normal. On the eleventh day the baby appeared apathetic, restless, and nursed poorly; the abdomen was more distended and he vomited once; the temperature arose to 101°F. On the twelfth day the abdomen was more distended and vomiting occurred several times. The child was more restless and the temperature arose to 102°F. The diagnosis of peritonitis of unknown origin was made and operation advised.

Laparotomy under light ether anesthesia revealed much free purulent fluid in the peritoneal cavity and a small amount of free feces. A loop of ileum was densely adherent to the right lobe of the liver and in the right flank anterior to the ascending colon. These adhesions were fibrous and very evidently of long standing. The adherent loop and its mesentery were twisted several times at the base, forming a volvulus, and parts of the loop were gangrenous with a resultant perforation. Other dense adhesions were found in the right upper quadrant. The appendix was visualized but was normal except for some reddening. Twelve inches of gangrenous ileum were freed by rather difficult dissection, brought out on the abdomen, excised and a tube sewed in each limb as the child was in too poor condition for a more lengthy surgical procedure. The abdomen was thoroughly drained and loosely closed. The child lived for thirty-eight hours. Vomiting occurred repeatedly, the bowels however moving about ten times before death. Postmortem examination revealed no other congenital anomaly of the abdominal viscera.

About eighteen months later Dr. H. B. Tebbetts delivered the mother of another apparently healthy baby. The subsequent history and findings, the operation and postmortem findings practically duplicated those of the case presented.

A number of causes of acute intestinal obstruction in the newborn have been described. One of the less common but of unique interest is a fetal peritonitis. Neff states: "In fetal life a rare chronic form of peritonitis may occur and is sometimes ascribed to the absorption of toxins or infections from the mother." Lues and tuberculosis have been generally considered the most common primary causes. According to Grulle: "It is the general consensus of opinion that, when present, fetal peritonitis is the result rather than the cause of obstruction" and "in practically all instances the cause may be found in some developmental error."

In the case reported it is believed that a fetal peritonitis had occurred and was the primary factor in the formation of the intestinal obstruction and that the adhesions formed therefrom prepared the way for the volvulus. The reasons are: 1. The very evident chronicity of the adhesions, these being too dense and fibrous to have formed since birth. 2. No apparent atresia or defect in the continuity of the bowel lumen until the volvulus occurred. 3. No embryologic anomaly that can adequately explain the conditions found. The sequence of events probably was this: a peritonitis, developing during fetal life, with adhesions forming between the ileum and other structures; the formation of a volvulus with the fixed portion of the ileum as a pivot; intestinal gangrene; perforation; acute peritonitis and death.

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COMMON ERRORS IN THE DIAGNOSIS OF RECTAL TUMORS*

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TOO frequently we find malignant tumors in the rectum and sigmoid which are inoperable, but which might have responded to treatment if discovered earlier. There are several factors in the examination of the rectum and sigmoid, which, being neglected or misinterpreted, may lead to error in diagnosis, especially of these conditions.

Such remarks as "the *x*-ray examination was negative"; "proctoscopic to 8 inches was negative"; "mass felt or seen at a level of 5 inches"; "there is no pain or symptoms of obstruction"; or "the stool is not ribbon shaped"; or "the bowels move regularly"; are often heard.

A negative finding by fluoroscopic or plate examination of a barium enema is of no value, and this fact is emphasized by the roentgenologist. This can be explained by the anatomical structure of the rectum and sigmoid, which allows a wide variation in size and shape when filled with the opaque enema. There is no typical picture of a normal bowel. Although a cancer mass may almost completely obstruct the lumen of the bowel in the rectosigmoid region, the opaque material passes through rapidly, filling the loops posteriorly, masking the filling defect from view. The irregularities of the mass are filled with the material which also obscures the true condition.

An opaque enema which shows a defect is not sufficient to establish the true diagnosis, as to position and extent of the lesion. Due to the looping and mobility of the sigmoid, the lesion may appear in the plate to be above the reach of the proctoscope and still be visualized at 5 or 6 inches. When an *x*-ray examination is considered necessary, and a defect found, the plate of an ingested opaque meal should be taken in order that the length of bowel above the lesion may be determined.

Incorrect proctoscopic examinations may be attributed to improper position, poor lighting, and unsuitable instruments. The distance the scope is inserted is often misjudged, probably because the examiner is not careful in measuring from the anus itself and may include a portion of the buttocks in the estimate. The same factors may account for the impression of a mass being felt at about 5 inches. Change in the bowel habit may be gradual. If the tumor is above the rectum proper, the fecal stream may dribble through and fill the ampulla, and the patient may still have fairly normal stools. If the mass is above the anorectal line, pain is usually a late symptom and is caused by the tumor encroaching upon surrounding tissues. Bleeding may go unnoticed for many months, or may be attributed to piles, and in the absence of pain does not impress the patient sufficiently, and too frequently the doctor makes the mistake of treating for piles without a proctoscopic examination. Bleeding frequently comes from polyps situated above the reach of the finger or anoscope. Single or multiple polyps, and even simple adenomato, often are precancerous, or have definite malignant changes without giving important symptoms. The finding of parasites in the stools of patients with bleeding and frequency has many times allowed a cancer to grow into an inoperable stage. Amebae have been found in the ulcers of a carcinoma. The shape of the stool means nothing, and depends upon the tone and condition of the opening through which it last passed.

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BENIGN NEOPLASMS OF THE STOMACH*

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BENIGN tumors of the stomach are of unusual interest to the surgeon because of their rarity and the serious complications which they may produce as well as the possibility of overlooking them in the course of a routine examination and because they can be dealt with only by surgical means. The symptoms suggested by such tumors are obscure chronic anemia, unexplained indigestion and sudden hemorrhage from the stomach.

It is interesting to note that the diagnosis of benign tumors of the stomach has rarely, if ever, been made before operation. They have usually been discovered as an accidental finding or at autopsy. Some idea of the rarity of the disease may be obtained by the fact that Alfred Tilger (quoted by Myer) in 3500 necropsies reports but 14 benign tumors of the stomach. In the Obruchow Krankenhaus in 7500 necropsies, 4 cases of polyps of the stomach were found. In the Russian hospitals, Tilgar found the percentage to vary from 0.007 to 0.04 per cent. Vegele, in 1908, reported one case of polyadenoma, and in a search of recent German and English literature was able to find a treatment of the subject in the works of Collier, Hanser, Post, and Galland. In French literature Menetrier, Brussard, and Norman have reported cases.

Up to March, 1927 at the Mayo Clinic "there had been 35 cases of benign tumors of the stomach in the males and 23 in the females. The youngest of these patients was eight years of age and the oldest sixty-nine. As to location, 69 per cent were in the pylorus, 26 in the body of the stomach and 5 per cent in the cardia."

These tumors may develop in any part of the stomach and may form on either the inside or the outside of the wall, varying in size from that of a pea to a baby's head. They may arise from any of the three coats of the stomach and may be either sessile or pedunculated, at times simulating carcinoma or sarcoma so closely that they cannot be differentiated except through most careful pathological examination. Some of them even metastasize with characteristics that simulate malignancy.

PATHOLOGY

There are a number of different benign tumors that may occur in the stomach. Among the more important of these may be mentioned mucous polyps, myomata, fibromata, lipomata, lymphadenomata, myxomata, osteomata, fibromyomata, adenomata, cysts of different types and syphilitic tumors.

Mucous Polyps. Microscopically, these are composed of the same tissues as a normal mucosa. According to Fenwick, they are really small adenomata that have undergone cystic degeneration. Two types are distinguished by Menetrier: a superficial one involving the excretory ducts and associated with much lobulation and many cysts from the connective-tissue obstruction of the duct; and a deeper form involving the glandular portion mainly, and showing little or no lobulation and few or no cysts. A mixed type occurs also. Polyps may be single or multiple; the latter may number as many as three hundred. To the multiple form the designation of the polyadenomata or polyposis has been given. Single mucous polyps are found frequently near the pylorus and the multiple in the median portion of the stomach. They form soft, slimy, globular or more or less lobulated, or even cylindrical or mushroom-shaped tumors attached to the walls of the organ by a thin stalk or pedicle, and varying

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in size from that of a wheat grain to several inches in length. The solitary polyp usually measures from ½ to 4 inches; the multiple

Fig. 1.

Fig. 2.

seldom exceed ¾ inch in length, are fairly uniform in size, and have been compared to a bunch of grapes. The color varies with the vascularity, from a gray to a deep red brown. The surface is smooth and never adherent.

Reports vary as to the frequency of their occurrence. Thus Ebstein found them present 14 times in 600 autopsies, whereas in 7500 autopsies at the Obruchow Krankenhaus only 4 cases of polyps were discovered and Fenwick states they did not exceed 0.2 per cent of the London cases.

As regards the etiology of the gastric polyadenomata, a number of explanations have been advanced but none has been universally accepted. The causes assigned include chronic alcoholism, chronic gastritis, atheroma of the gastric vessels, and other conditions leading to chronic nutritional disturbances of the mucosa. Plausible as these are in individual cases, no one of them would appear applicable to all. The most probable conducive factor is chronic gastritis, which so frequently results in hypertrophic thickening and lobulated swellings of the mucous membrane and finally may lead to the development of smaller or larger polypoid formations. However, Aschoff believes this sequence to be exceptional and that the catarrh is secondary to the polyposis. In this connection, attention may be directed to the association of catarrhal enteritis with polyposis intestinalis and the reported disappearance of the latter after the amelioration of the catarrhal process from colonic irrigation through a colostomy opening.

Myomata. The myoma is a common form of benign tumor of the stomach. Most of these cases, however, proved to be malignant, showing areas of fibro-sarcomatous or myosarcomatous degeneration. Myomata may be single or multiple and are usually situated in the pyloric region,

forming firm rounded tumors. Von Erlach removed a myoma said to have weighed 5400 gm., von Eiselberg one the size of a

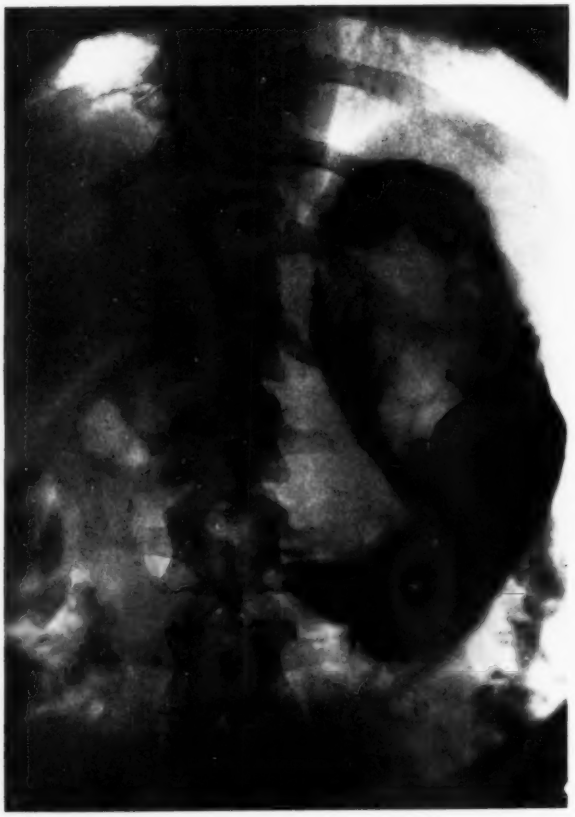

Fig. 3.

man's head, and Kunze a lipomyoma of 251 gm. The submucous variety may undergo cystic, and the subserous, carcinomatous degeneration. Microscopically they consist of unstriated muscle fibers mixed with strands of fibrous tissue.

Fibromata. These may be single or multiple, and are usually situated in the pyloric region. As a rule they are elongated or club shaped and measure from 1 to 4 inches in length. Occasionally they assume a globular form. Microscopically they either present a papillomatous structure or consist entirely of fibrous tissue covered with thin mucous membrane. Fenwick doubts the identity of reported cases of simple intramural fibromata of the stomach. He believes that they are either ordinary scirrhous carcinomata, fibrosarcomata or keloids formed from the scar of a former ulcer. He says: "We have not been able to find a single case in all the literature of a large fibroid tumor of the gastric walls above suspicion."

Lipomata. The lipomata are very rare, are usually solitary, and are generally situated in the central part of the stomach, on the anterior wall. They originate in either the submucous or subserous coats and, pushing these back, project as small or even very large pendulous masses into the cavity of the viscus or into the abdomen. Very rarely they may be diffused and spread over a large area of the stomach wall. In rare instances they may undergo cystic or malignant degeneration.

Lymphadenomata. This is a peculiar form of gastric tumor due to an overgrowth of the normal lymphoid tissues. It may develop either in the mucosa, forming numerous polypoid and sessile tumors which project into the lumen and infiltrate the walls of the organ, or it may originate externally in the mesenteric glands and invade the stomach through the serosa. The growth may be widely disseminated and frequently there is a general enlargement of the systemic lymphatic glands similar to that occurring in Hodgkin's disease. The pyloric region appears to be singularly free from these growths. They are soft, smooth and creamy white, frequently undergoing superficial ulceration or softening at their base, and even gangrene. Microscopically, they consist of thickened folds of mucous membrane infiltrated with lymphoid elements. The submucous coat is often unaffected.

Myxomata are gelatinous, semi-transparent tumors, encapsulated in the walls of the stomach and covered by mucous membrane. Only 3 cases have been reported, including one by Hansemann.

Osteomata are really fibromata and sarcomata which have undergone partial ossification. The best known case is that reported by Webster in 1827.

Fibromyomata when pedunculated take the form of firm rounded tumors which

vary from the size of a pea to that of an orange, and are attached to the wall of the stomach by a thin pedicle. They may be single or multiple, and are usually situated in the pyloric region.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Adenomata. These are composed of the same structural elements as are mucous polyps. But while the latter are mainly composed of mucous membrane true adenomata consist of more or less tortuous, irregularly dilated tubular glands supported by connective tissue and well supplied with blood vessels. The overlying mucous membrane is affected by chronic interstitial inflammation. The pedundulated variety is most frequently situated in the pyloric region.

Adenomata form rather firm, smooth, round or somewhat lobulated tumors occasionally cystic in part, the cyst being filled with brown mucous. They may be single or multiple. When multiple, they rarely attain a size larger than a walnut. Single ones vary greatly in dimensions, the largest recorded being a pedunculated one successfully removed by Chaput, which was the size of a fetal head at term.

A most important fact in connection with adenomata is their close association with carcinomata. Not only is it at times very difficult to differentiate between the two histologically, but even where the microscopical evidence favors benignancy, the clinical course and gross appearance may bespeak a malignant type of disease.

Cysts. Seven varieties of cysts have been noted. The most common are retention cysts met in obstruction of the mouth of the ducts of the gastric glands in chronic gastritis. Other varieties that have been described are dermoid, serous, hydatid, blood, lymphangiomatous or chylous cysts, and those cysts formed through degeneration.

Syphilis. According to Fenwick, syphilis may affect the stomach in three ways: (1) by the formation of gummata; (2) by the production of endarteritis, and (3) by exciting chronic inflammation in its mucous membrane. He states that gummata of

sufficient size to attract attention are rarely encountered, and that only a few genuine cases are recorded in the literature on the subject.

SYMPTOMATOLOGY

Benign tumors of the stomach may exist throughout life without evidence of any clinical symptoms. This is particularly the case with polyadenomata. Quite a number of such cases have been reported, the majority, however, having been found at the time of autopsy following death from other conditions. It is a curious and interesting fact that death has resulted in most of these cases from cardiovascular or renal conditions, and that associated with these tumors is often found a condition of chronic hypertrophic gastritis. A number of observers have considered that the disturbed nutrition of the gastric mucosa is an etiological factor in the production of these growths. This, however, has not been proved, for cases have been found in which gastritis was not present. It has also been suggested that the presence of cardiovascular conditions might be a causative factor in the growth of these tumors, but this is not probable. When these benign tumors are situated near the pylorus they may be provocative of most serious symptoms. Various degrees of stenosis may be produced. Death may result from hemorrhage or by ulceration through the stomach wall. Violent exacerbations of pain may be present during the active process of digestion.

The clinical picture presented by this group of tumors varies within the widest ranges from complete euphoria and utter unconsciousness of gastric changes to conditions fraught with grave consequences to health and life. This diversity of manifestations depends largely upon the size, location, and nature of the growth. Intramural growths, of small or even quite large size, located at a distance from the pylorus, may give rise to no appreciable symptoms. Large ones are prone to manifest themselves through their mechanical effect, producing a sense of epigastric weight and dragging. Frequently there are present dyspeptic manifestations of various degrees; loss of appetite, loss of body weight, anemia, and even pain. Such large growths are usually palpable through the abdominal parietes.

Where the growth is located in the pyloric region, and especially if it is pedunculated, it is more apt to be associated with active dyspeptic symptoms such as have just been mentioned. Epigastric or hypochondriac pains seem to be one of the most constant manifestations. A frequent tendency of pedunculated growths of all types near the pylorus is to prolapse into this opening and cause a partial or complete obstruction. This gives rise to very violent attacks of pain with nausea, and more or less protracted vomiting. Depending upon the degree of obstruction, there results more or less gastric distention, food retention, and peristaltic rigidity. Frequently there is blood in the vomited matter. The obstruction occurs through a ball-valve action and in most cases is only temporary, the tumor falling back into the stomach and a longer or shorter period of quiescence ensues, to be interrupted again by other attacks of acute obstruction, until finally death occurs or they are relieved by operation. The acute obstructive attack is often the first active manifestation of the disease. Cleghorn reports the occurrence of a pyloric perforation during an attack. This is very rare. More frequently there is intussusception. The stomach may be intussuscepted into the duodenum, as in a case recorded by Collier, or even the duodenum and part of the stomach into the jejunum, as in Wad's unique case. The tumor in Wad's case was a non-pedunculated fibromyoma near the pylorus.

When the tumor involves the mucous membrane, hemorrhage is a frequent symptom. It is due to excessive vascularity of the growth of the surrounding mucosa, or to the erosion of a vessel by ulceration or sloughing. The blood may be visible or

occult in the stomach contents or stools. As a rule even though profuse, the hemorrhage is without serious consequences. Launersh great multiplicity of goblet cells; such a finding, he believes, should always arouse suspicion of a polyposis. The diagnosis in

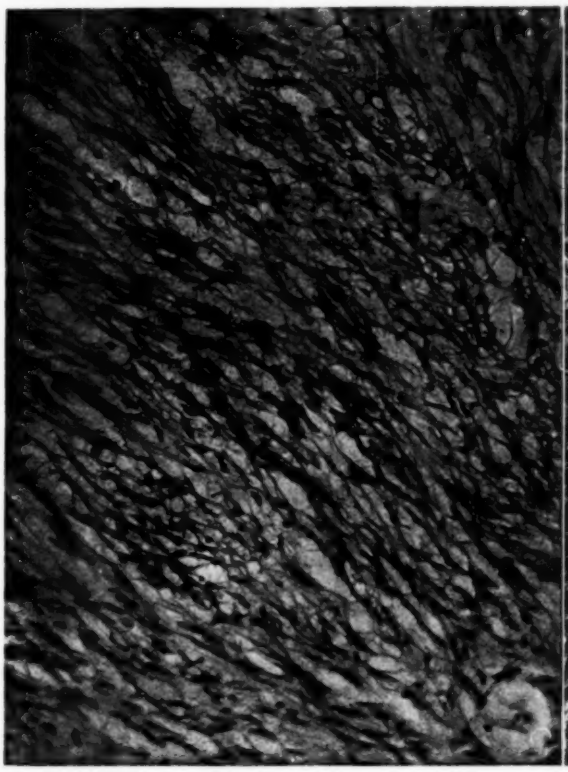

Fig. 8.

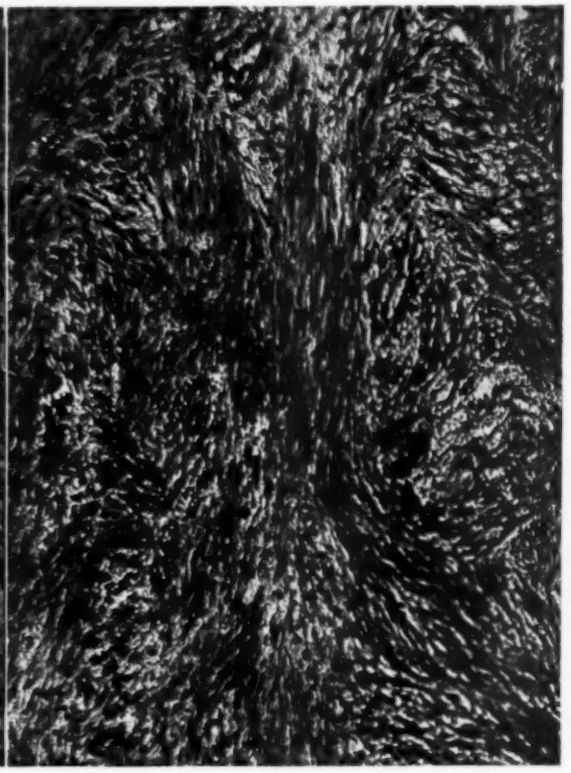

Fig. 9.

and Kemicke have reported cases in which it proved fatal. It is difficult to formulate rules of diagnosis regarding stomach content examinations aside from the period of acute obstruction. The majority of case reports include no data on this subject. From the few recorded cases and theoretical considerations, we may safely conclude that where the mucous membrane is not involved and there is no obstruction from the growth, normal conditions of motility and secretion should prevail. Where, however, the growth is one essentially of the mucous membrane, as in mucous polyps of the multiple as well as of the single types, achylia has been reported (Myer 1; Wegele 23; Chosrojeff, 23; Campbell, 23). Myer points out that the achylia is not an ordinary simple one, but is associated with excessive production of mucus, like egg-white, such as might be expected with several cases has been rendered possible by finding a tumor fragment in the vomitus, wash water, or feces.

ROENTGENOLOGY

The recent rapid development of radiological diagnosis, particularly the direct demonstration of abnormal conditions in the diagnosis of these tumors, is the best means short of the actual demonstration of the growth itself. I do not see how a diagnosis can be made of those tumors which are not palpable without the use of the *x*-ray and as all of us are thoroughly familiar with the importance of the *x*-ray it would be useless for me to elaborate on this common means of diagnosis.

CASE REPORT

Summary: Patient presenting no symptoms of stomach pathology excepting severe gastric

hemorrhage, one late in 1926, and one three weeks before operation; *x*-ray diagnosis of papilloma or cancer of the cardiac end and upper third of lesser curvature of stomach; at operation fibromyoma of stomach found and removed.

On June 17, 1929, Mrs. M. L., aged forty, No. 26948, entered the hospital because of hemorrhage from the stomach, weakness and for *x*-ray study.

Family History: Father died at the age of fifty-seven with apoplexy. Mother is living and well at the age of seventy-nine. The patient has two brothers and three sisters living and well.

Past History: The patient had scarlet fever and typhoid fever as a child; had an appendectomy and uterine suspension in 1922. She has three children living and well, aged twelve, eleven and nine, and no miscarriages. She has had frontal sinus trouble since 1928. Tonsillectomy was performed in May, 1929. In June, 1926, the patient contracted an acute cold; at this time she had considerable palpitation of the heart and three days after its onset, she had two severe hemorrhages from the stomach. The patient attributes this hemorrhage to some medicine she had taken for her pleurisy. Following this attack of hemorrhages, she was put on a Sippy diet for six weeks and did not have any pain, vomiting or discomfort and was able to take almost any sort of food. The patient was practically free from symptoms, except for a feeling of fullness and discomfort on pressure in the epigastrium. On June 2, 1929, she had an unusual desire to defecate and the stools were black. Later in the night of June 2, 1929, she vomited bright red blood with clots. This attack followed a considerable amount of physical exertion on the day and evening before. She was extremely exhausted and tired on the day of this hemorrhage. Her last menstruation was June 6, 1929, which was normal. There had been no recent loss of weight. Her habits were the very best; she does not drink, smoke or use tea or coffee.

Physical Examination: The patient was well nourished. Pulse 72; temperature 98; and skin very pale; blood pressure 108/70. The head had no abnormalities in shape or size; no growths or other irregularities. The teeth were in good condition. No glandular enlargements were noted in the neck; no abnormal pulsations; no enlargement of the thyroid. Chest: The heart was not enlarged. There was a slight mitral systolic murmur at the apex in the fifth interspace. Lungs: Careful examination revealed no abnormalities to inspection, auscultation, or percussion, there being no area of dullness; diaphragm excursions were normal on both sides; there was no retraction of any interspaces; no râles were heard over any portion. Genitourinary Tract: Negative. Extremities: These were normal in every particular, showing no atrophy, no loss of motion, no arthritis. Reflexes: Plantar, anterior tibial, knee jerk, abdominal and forearm reflexes were not exaggerated and were responding equally on both sides. Abdomen: There were no abnormalities in shape, size, or general contour of abdomen on inspection. No masses were palpable. There was an old scar in the midline below the umbilicus from an operation some years ago. Slight tenderness over the epigastrium was noticed on deep pressure.

Laboratory Report: Blood count June 17, 1929: Hemoglobin, 40; red blood cells 3,200,000; white, 6300, Polymorphonuclears 68 per cent, lymphocytes 32 per cent. After transfusion of 500 c.c. of whole blood, June 28, 1929: Hemoglobin, 60; R.B.C. 4,250,000; W.B.C. 8000, Polymorphonuclears 69 per cent, lymphocytes 31 per cent, Ind. 7.

Urinalysis was negative at all times.

X-ray pictures were taken of this patient during her first few days in the hospital and there was no evidence of pathology found by the fluoroscope in the erect position. However an examination a few days later in the reclining position showed a defect in the posterior wall of the stomach near the cardiac end which will be observed in the accompanying *x*-ray plates.

The site of these tumors is usually at the pyloric end of the stomach and the fact that this one was near the cardia makes the case which I am reporting interesting not only because of the location in the stomach, but because of the rarity of such tumors in this organ.

Operation was performed (procedure described in discussion).

Further History: The patient made an uneventful recovery. She did not vomit once after operation. The stitches were removed on the eighth day and in the early part of the ninth day, the patient had a spell of coughing and experienced a pain in the left lower quadrant, but the pain disappeared on the third day.

During these three days, her temperature was 102°F. She left the hospital on the sixteenth day after operation and now reports herself free from digestive disturbances.

Pathological Report: The specimen is a tumor mass, measuring 9.5 cm. in length by 5 by 5 cm. On one edge of it there is mucous membrane with some ulceration. The rest of the surface is rather firm and grayish with a yellowish tint indicating a fatty or degenerative process. Attached to this is a smaller tumor, measuring 6 by 3.5 by 2.25 cm. It is similar in form to the other and on section shows a cystic cavity, whose inner lining is rough with fibrous tissue strands running through it. Its contents were a clear mucinous fluid. This has the same general structure as the larger tumor. Microscopical findings: The section shows a neoplastic growth composed of fibrous tissue and smooth muscle cells. It is quite typical of bundles interlacing and some areas showing degeneration. There is no evidence of malignancy.

CONCLUSION

This case has been very instructive to me and has stimulated me to consider the possibility of the existence of benign tumors in obscure cases of gastro-intestinal disorders, associated with the presence of occult blood in the stools. It has also drawn personal attention to the fact that in operating upon tumors of the stomach, one should bear in mind that while benign tumors of this organ are rare, they are not so rare but that they should be considered in deciding upon a surgical procedure.

It is my hope that the readers of this article will note that the condition is not as frequent as it might appear at first thought and that cases that are unusual or are undiagnosed should be more thoroughly *x*-rayed and operated upon earlier.

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DISCUSSION

Dr. Harlan Shoemaker: The outstanding feature in this paper is the diagnosis by the roentgenologist, Dr. J. W. Warren. *X*-rays are taken, as a rule, in the prone position. Such an *x*-ray would have entirely missed this tumor of the stomach; an *x*-ray in the dorsal position very distinctly outlined the tumor.

Dr. A. A. Blatherwick: It was my privilege to assist Dr. Johnson in this operation. This diagnosis was made largely on the history of severe, recurrent hemorrhages, in the absence of the usual symptoms of carcinoma or ulcer of the stomach. The roentgenologic examination confirmed the diagnosis.

A short description of the technique of the operation may be of interest: After exposing the stomach in the usual manner, an incision about 3 inches long was made in an avascular area of the anterior wall of the stomach. The tumor, which was in the posterior wall, was everted through the incision in the anterior wall. An incision was then made through the mucosa, extending around the ulcerated surface over the tumor, an area about one inch in diameter. The tumor was then shelled out of its capsule in a manner very similar to that employed in removing a fibroid from a uterus. The serosa on the posterior wall of the stomach was not opened. Closure of the site from which the tumor was removed was accomplished by two rows of chromic sutures bringing the muscles and mucosa together. The incision in the anterior wall of the stomach was repaired and the abdomen closed without drainage.

Dr. Johnson (*closing*): I do not believe this tumor would have been discovered if the patient had not been put in a dorsal position, as the barium would not have collected around it because it was too high in the cardiac end.

PSEUDOMENSTRUATION IN THE HUMAN FEMALE*

CHARLES MAZER, M.D., F.A.C.S., AND A. J. ZISERMAN, M.D.

PHILADELPHIA

AS a preliminary to the discussion on the occurrence of pseudomenstruation in the human female, it is essential to review briefly the mechanism of the normal menstrual cycle.

As early as 1908, Hitschmann and Adler[1] demonstrated the cyclical changes in the endometrium of the normal human female; in 1913, Schröder[2] correlated these cyclical endometrial changes with the corresponding rhythmic phenomena in the ovaries.

According to our present conception of the probable mechanism of the menstrual cycle from recent experimental evidence, the rhythmic intermittency of female sex hormone production by the Graafian follicle and its successor, the corpus luteum, under stimulation from the anterior pituitary lobe (Smith[3] and Zondek[4]) is responsible for the cyclical endometrial growth and its subsequent dismantling in the form of menstruation. This assumption is supported by the experimental induction of menstruation in the castrated monkey by the administration of female sex hormone (Allen[5] and Morrell[6]). These experimental observations coupled with others soon to be mentioned seem to indicate that female sex hormone supplies the essential mechanism of menstruation. As will be seen later this form of menstruation lacks the progestational phase.

In addition to producing the female sex hormone, the mature corpus luteum elaborates a water soluble principle known as "progestin" or inhibitory hormone, the function of which is mainly to sensitize and prepare the endometrium for nidation and to inhibit further development of Graafian follicles. The secretory or premenstrual stage of the uterine mucosa, including the pseudodecidual reaction in the compact layer, is due to the latter hormone. This was first suggested by Fraenkel[7] and recently corroborated by Weichert[8] and Corner and Allen.[9] They proved the absolute dependence of the secretory phase of the menstrual cycle upon the hormone, "progestin," simultaneously produced by the corpus luteum.

The premenstrual endometrium differs from the interval endometrium in that it is thicker; the glands are cork-screw in appearance and distended with secretion; the nuclei of the columnar epithelial cells lining the lumen of the glands are eccentrically located; the blood supply is abundant; the stroma is edematous and contains numerous pseudodecidual cells.

Whether the rhythmic periodicity of anterior pituitary lobe function upon which ovarian function depends is inherent or is controlled by forces unknown to us is a matter of conjecture. Nor is it definitely known that the anterior pituitary gland produces two individual sex hormones, a follicle ripening (prolan A) and a luteinizing hormone (prolan B). In our experience, the luteinizing hormone (prolan B) now available is capable of ripening the primordial follicles of immature animals. This and other observations lead us to believe in the existence of only one pituitary sex hormone.

PSEUDOMENSTRUATION IN THE MONKEY

That cyclical uterine bleeding is always the culmination of maturation of the Graafian follicle and regression of its successor, the corpus luteum, following the failure of fertilization, was doubted by Heape[10] and later by Van Herwerden[11] as a result of their observations on preserved uteri of the Macacus rhesus. Corner[12] definitely established the occurrence of

anovular menstruation in this species as a non-seasonal event. He also showed that anovular cyclical bleeding is invariably associated with an interval endometrium, presumably because of the absence of the corpus luteum.

Further experimental proof that menstruation without ovulation and without the presence of a premenstrual endometrium is possible in the Macacus rhesus was furnished by Robertson[13] and others who observed uterine bleeding in the castrated Macacus rhesus after the withdrawal of injections of female sex hormone.

The observations by Heape, Van Herwerden, Corner and Robertson on the Macacus rhesus permit the following conclusions:

(a) Menstruation without ovulation is a regular occurrence in the Macacus rhesus during the non-breeding season; and that it is a non-seasonal event in a large number of the species.

(b) When an interval endometrium is found at the beginning of menstruation, there is a total absence of ovulation and corpora lutea.

PSEUDOMENSTRUATION IN THE HUMAN FEMALE

The sexual cycle of the Macacus rhesus duplicates that of the human female in time, periodicity and the occurrence of actual hemorrhage; therefore, comparison with that of our own species is scientifically sound.

The absence of ovulation and a corpus luteum in the last phase of the menstrual cycle was observed by some in the course of abdominal operations on regularly menstruating women, free from pelvic disease. Thus, a careful observer like Allen[14] says: "In one or two cases the evidence clearly points to absence of ovulation in the last several cycles. This condition, menstruation without ovulation, so common in the monkey, must be recognized as occurring in women."

An illustrative case came under our observation recently:

Mrs. R. R., aged twenty-three, and the mother of a two-year old child. Menstruation began at the age of eighteen, when her periods became delayed and somewhat irregular. She was admitted to the Mount Sinai Hospital on September 24, 1930, with a diagnosis of acute appendicitis and retroversion of the uterus. A lower median incision was made to permit also correction of the retroversion. She was menstruating at the time of operation. Both ovaries were somewhat enlarged and studded with numerous small cysts. The ovarian tunic of both ovaries seemed thick. Numerous punctures were made to evacuate the cysts. There was no evidence of either recent or old corpus luteum.

With these thoughts in mind, we investigated the microscopic appearance of the endometrium and, simultaneously, the blood-hormone content of a series of 41 regularly menstruating sterile women, whom we curetted a day or two before the expected flow and, simultaneously, abstracted 80 c.c. of venous blood to determine the level of female-sex-hormone by the Frank and Goldberger method.[15] For the sake of accuracy, we ran a duplicate test simultaneously in each case. Careful study of these women revealed no apparent cause for the existing sterility. The patency of the Fallopian tubes and proper insemination of the cervix had been previously established. Pelvic examination, basal metabolism tests and complete medical study had eliminated, as far as possible, local and constitutional causes for the existing sterility. They were therefore classed as cases of functional sterility. The results, as tabulated below, show that 24 of the 41 regularly menstruating functionally sterile women subjected to premenstrual curettage showed a non-nidatory endometrium, indicating defective luteinization or a total absence of the corpus luteum.

Women who suffer from menstrual derangements are either totally sterile or have a low fertility, but one hesitates to attribute an existing sterility to an endocrine cause in a woman whose menstrual cycle is normal, though there is no other ascertainable condition to account for the

sterility. This method of investigation is therefore helpful in the diagnosis of sterility in regularly menstruating women. A typical case history follows:

L. C., aged thirty-two, has been married twelve years and was never pregnant. She began to menstruate at the usual age but the intervals until marriage were somewhat prolonged. She is of average height and weight and presents no stigmas of an endocrine malfunction. Blood count, blood Wassermann reaction, urine and basal metabolism rate are normal. The uterine body is small and anteverted; the cervix long and narrow; the external os pin-point. There is no palpable pathology in the adnexa and no evidence of cervical infection. Well formed motile spermatozoa were found in the cervix four hours following intercourse. The Rubin test showed patency of the Fallopian tubes at the low pressure. Eighty cubic centimeters of venous blood, abstracted two days before her expected period and treated by the Frank and Goldberger method, produced no reaction in two castrated female white mice. The uterine scrapings, obtained simultaneously, showed an interval stage with areas of hyperplasia.

The failure to find a premenstrual endometrium and a demonstrable quantity of female sex hormone two days before the expected flow in a woman who has been menstruating regularly for twelve years is sufficient evidence of ovarian dysfunction —defective luteinization.

Table 1
Relationship Between the Condition of the Endometrium and the Level of Female Sex Hormone

Premenstrual endometrial findings	Female sex hormone level			
	Normal	Threshold	Neg.	Total
Interval endometrium	0	1	11	12
Hyperplasia	1	2	5	8
Premenstrual endometrium with local hyperplasia	0	0	4	4
Premenstrual	6	6	5	17
Total	7	9	25	41

Group I. In this series of 41 regularly menstruating apparently functionally sterile women, 12 yielded an interval endometrium a few days before the expected onset of the menstrual flow; in 8 we found a well-marked endometrial hyperplasia. Only 1 of the 20 in this group showed a normal level of female sex hormone in the blood; 3 showed only a threshold quantity; the remaining 16 showed no demonstrable quantity of the hormone.

Group II. In 4 of these women, we found a premenstrual endometrium with local hyperplasia. None showed a demonstrable quantity of female sex hormone.

Group III. In 17 women we found evidence of a premenstrual endometrium. Six of these showed a normal level of female sex hormone; 6 a threshold quantity; and the remaining 5 showed no demonstrable quantity of the hormone.

The significance of the absence of a demonstrable quantity of female sex hormone in the circulating blood a few days before the expected flow was stressed by Frank and Goldberger[15] and others. It assumes greater importance when a duplicate test is run simultaneously as in our cases, because in a large series of tests on normal fertile women, we obtained a positive reaction in no less than 94 per cent. It is therefore possible that even those women in Group III who showed a premenstrual endometrium but no demonstrable quantity of female sex hormone are also hypofunctioning.

This constitutes the first detailed report in the literature of the finding of a nonnidatory endometrium a day or two before the expected flow in regularly menstruating women. Passing mention of this observation has been made by one of us[16,17] in former publications. These findings suggest, by inference, the possible failure of ovulation and corpus luteum formation similar to the condition often found in the Macacus rhesus.

The findings in the first group substantiate the current belief that the balanced action of female sex hormone and the nidatory principle of the corpus luteum is the responsible factor in the preparation of the normal premenstrual endometrium.

They also explain the underlying cause for the existing sterility in these women and suggest rational therapy, namely, the administration of appropriate quantities of female sex hormone followed by the administration of lutein hormone during the latter half of the menstrual cycle. Unfortunately, the latter, so essential in the preparation of the endometrium for nidation, is not available for therapeutic use because of the meager source of supply. Female sex hormone, alone, is usually inadequate in the treatment of functional female sterility. Furthermore, the underlying cause of ovarian hypofunction is usually a lack of anterior pituitary sex hormone upon which the ovaries depend. Hence the treatment should, in most cases, be directed to the pituitary gland if clinical and laboratory findings point to an anterior pituitary deficiency.

Fortunately, we now have at our disposal potent products of anterior pituitary sex hormone, the dosage of which, however, has not yet been determined. The luteinization effect of this hormone has been established experimentally. The possibility of hyperluteinization with suppression of estrus through the use of excessive doses was also observed experimentally. It is therefore difficult to determine the exact dose necessary to increase luteinization without ill effects in the human female. In 3 of 15 women belonging to this class, we observed delay in the expected menstrual cycle from five to seven days after the administration of apparently excessive doses of the hormone. Clinically, the administration of 20 R. U. every other day during the latter half of the menstrual cycle has given us encouraging results.

We cannot explain the infertility of those women, in this series, who presented a normal endometrium and a demonstrable quantity of female sex hormone, on the basis of endocrine hypofunction. We feel that undetermined causes, such as sexual incompatibility, may be the causative factors.

SUMMARY

Amenorrheic and irregularly menstruating women are admittedly hypofunctioning; women who menstruate regularly and in whom there is no demonstrable cause for the existing sterility present a problem in diagnosis. In these women, a premenstrual curettage and the simultaneous determination of the hormone content of the blood by the Frank and Goldberger method are invaluable from the standpoint of diagnosis and treatment. The failure to obtain a premenstrual endometrium and a mouse unit of female sex hormone a day or two before the expected flow in regularly menstruating women is indicative of ovarian dysfunction, either primary or secondary to anterior pituitary deficiency.

For the following reasons we may infer that these women do not ovulate:

(a) In the human and the Macacus rhesus, the presence of a normal corpus luteum is invariably associated with a progestational endometrium.

(b) An interval endometrium in the Macacus rhesus obtained at the onset of the flow is invariably associated with an absence of ovulation and corpus luteum.

(c) In the course of abdominal operations on regularly menstruating women, who were at the end of the menstrual cycle, some surgeons occasionally found a total absence of a recent or old corpus luteum.

(d) The absence of a demonstrable quantity of female sex hormone in the circulating blood a few days before the ensuing menstruation also points to a possible failure of luteinization in view of the fact that 94 per cent of regularly menstruating fertile women show a positive reaction at this phase of the menstrual cycle.

The usefulness of organotherapy in these cases is limited because one of the two ovarian hormones, "progestin," so essential in the preparation of the premenstrual endometrium, is thus far not obtainable for therapeutic use. The luteinization hormone from the anterior pituitary lobe now avail-

able for therapeutic use gives promise of therapeutic results.

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SALT FREE DIET IN THE TREATMENT OF SURGICAL TUBERCULOSIS

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A SURVEY of the development of modern surgery shows clearly well-defined epochs. The aseptic era was followed by splendid technical developments. One anatomic complex of organs after another was conquered by surgical therapy.

The last field, thoracic surgery, could be perfected after Sauerbruch first applied his method of difference in atmospheric pressure. It is no coincidence that the same surgeon six years ago started with the research of a new problem in surgery: the diet.

The growing interest in physiological chemistry suggested a return from rather mechanical ideas to biology. Circumstances favored these events. Hermannsdorfer's experiments with acid and alkaline diet on wounds indicated the dietary influence on the healing process. Schade's findings on the chemical reaction of wounds seemed to confirm the clinical results. The acid reaction of wounds, the beneficial influence of ketonic diet on the healing process, the unhealthy aspect of wounds and slow formation of granulation during alkaline nutrition, all these facts outlined the experimental path to be followed. Gerson's dietetic therapy needed scientific investigation and received Sauerbruch's attention. Local conditions encouraged the work. The surgical clinic in Munich housed all kinds of tuberculosis patients. Lupus, surgical tuberculosis and phthisis were put under observation. Free from enthusiasm, even rather sceptically, did Sauerbruch and his staff start their work. Technical difficulties and numerous other obstacles had to be overcome. After a few months of pioneering they decided to investigate this problem from every possible angle.

Various theories existed about diet in tuberculosis. Nearly every-one of them was based upon the necessity of high caloric

FIGS. 1 and 2. (From Nissen-Myer Ruegg.)

value, since Brehmer's experience had shown time and again how beneficial so-called "fattening diets" proved in cases of tuberculosis. At present Hermannsdorfer allows 3100 calories daily, whereas Gerson administers only 2560 calories. This difference is partly due to a variation in protein intake, which Gerson limits to 60–70 gm. per week, while Hermannsdorfer gives much more. Theoretically a small amount seems not to be adequate. MacCann and other authors showed that the minimum nitrogen content in tuberculosis patients is about normal or somewhat increased, namely 2.4 – 9.5 gm. per day. It is possible sometimes to activate the protein balance by giving only 1 gm. of protein per kg. body weight. Gerson's small amount of protein is therefore even somewhat dangerous over long periods.

Hermannsdorfer and Gerson both allow carbohydrates in restricted amounts. Looking at this fact from a general viewpoint it seems rather difficult to under-

stand. We know that the French theory of usually severe dysfunction of the liver in tuberculosis is not justified. The levulosis test proves normal or almost normal liver function in tuberculosis patients. Carbohydrates are easily absorbed, have little or no dynamic effect, improve assimilation of fat and have an economical value for proteins. For these reasons Monceaux favors a large intake of carbohydrates and claims furthermore that they improve the detoxicating functions of the liver. The difference in carbohydrate estimation is evident if we compare the old opinion to the Gerson-Hermannsdorfer diet. An explanation will be given later.

Fats are allowed in abundance, a rather natural procedure. In addition cod liver oil is given combined with phosphorus. The value of phosphorus seems somewhat problematic. Straub's investigations showed that the phosphorus content in Hermannsdorfer's prescription varies very much for technical reasons so that the importance of phosphorus seems doubtful.

Much more interesting in fact is the main part of the diet: strict lack of salt. This rule was sternly followed by both Hermannsdorfer and Gerson, and sustained in spite of later changes and disagreements. There have always been different opinions about the role of salt in medicine. Our body really does not require much salt. There is no protein known which contains chlorine ions. Hydrochloric acid of the stomach is reabsorbed by the intestines and returns to the stomach. The regulation of osmotic conditions, the main work of NaCl in the body, is guaranteed by a very small amount of salt; 2 gm. daily are sufficient for our organism, a dosage which ordinarily is contained in food. Even this amount is already high compared to other mineral salts. Artificial increase of salt must cause an overbalance in the system and unnecessary work in elimination and storage.

Our way of cooking spoils the natural taste of food and makes additional spicing necessary. There is no substantiated reason for the opinion that a higher amount of salt is necessary than naturally provided in foods. We know people who practically do not use salt at all; and Hermannsdorfer and Gerson could demonstrate on many patients that lack of salt is not harmful.

Tuberculosis patients are comparatively poor on NaCl. Hermannsdorfer considers this as a self-defense of the organism and wants to help the body by future restrictions. He also claims that salt retains fluid. Deficiency of salt consequently diminishes the fluid and at the same time discharges from fistulas, granulations and so on. Anyone acquainted with this diet knows this change very well. Doubtless the lack of salt is responsible for this striking effect. Meyer-Bisch claims that a salt-free diet has not always a dehydrating effect and might produce NaCl retention; this observation certainly cannot be generalized.

But which one of the two ions in NaCl is the undesirable one? Recently the effect of Cl ions was found to be harmful. Keining and Hopf made interesting studies and now hold the Na ion responsible for disturbances in the chemistry of mineral salts.

Studying the role of NaCl in connection with the metabolism of all the mineral salts in the body, we have to deal with many difficulties. Demands, distributions and relations of the various inorganic salts depend on a multitude of organs in our body. Endocrine glands and the reticulo-endothelial apparatus play a role besides the nervous system.

Our skin is rich in mineral salts. Luithlen was the first to consider salt harmful in skin diseases. The Hermannsdorfer-Gerson diet gives excellent if not its best results in the treatment of lupus. This fact seems to prove the importance of NaCl and mineral metabolism in this diet. Robin's theory of demineralization was later corrected by Monceaux. He observed differences according to pathological-anatomical varieties and stages. There is a marked deficiency during the acute stage which becomes more balanced in the chronic course. The output of mineral-salts decreases as the organism tries to hold back these valuable

substances. An abundant intake of mineral salts is important because they are stored again in a slightly active balance already. In the final stage of the disease the body apparently loses its economical ability and the output increases. Gerson's idea to sustain the natural demand by administering mineralogen seems quite appropriate. Mineralogen contains 10 different mineral salts. Of course, it is true that large amounts of vegetable and fruit provide enough of these substances, and it is also true that some authors obtained the same results by Gerson's diet without mineralogen. But certainly no harm is done by this mixture, and if the body has no use for these substances it eliminates them.

Another reason for restriction of salt and changing to mineral salts is the so-called transmineralization which stimulates the system (Luithlen, Wiechowski). The sodium in the diet is extensively replaced by calcium, magnesium and strontium which confirms Keining and Hopf's aforementioned theory to hold the sodium responsible for ill-effects of salt. But sodium can be neutralized by administration of a salt which contains the minerals exactly in the same percentage as found in human serum. Titro salt is said to be effective in all diseases connected with the sympathetic nervous system. The use of titro salt in the Hermannsdorfer-Gerson diet could eliminate many technical difficulties. Evidently Hermannsdorfer does not consider this possibility. He finds it some what illogical, according to a private remark, to give a poison and its antidote at the same time. He prefers to omit it.

The diet is very rich in vitamins. To substitute phosphorus cod liver oil by vigantol is possible, but very exact dosing is necessary because an excess may produce bad effects.

Almost every article concerning this diet, and there are many, expresses a separate opinion on the chemical reaction of this regime. It may be mentioned again that the favorable effect of acid diet on wounds has been the fundamental idea for the combination of this diet. Hermannsdorfer's diet in its last form undoubtedly has a lower pH value than Gerson's who restricts meat more and more. He is nearing a complete vegetable fruit regime. R. Berg and others also claim an alkaline reaction of Hermannsdorfer's diet. The same discrepancy exists on the chemical action in the body. It must be said again that there is a great difference between a chemical reaction and the physicochemical reaction in the body. What tastes sour to us may be alkaline for the body and vice versa. Fruit contains fruit acids, but they are precipitated immediately and the alkaline components dominate.

Hermannsdorfer bases his opinion of the chemical reaction of his diet on urine examinations, but it remains questionable if this method furnishes useful results. The importance Sauerbruch gives this question may be best expressed in his own remark at the 1930 surgical congress: "I do not even know what pH really means."

This attitude sometimes can be applied in medicine. There are empirical items lacking theoretical base which give striking results, so from this point of view the diet certainly proved its therapeutic value.

The best results are obtained in lupus. Hermannsdorfer goes so far as to suggest treatment of one case of lupus wherever his diet is given in other kinds of tuberculosis. If the lupus case is cured, the preparation of the diet is done correctly.

The value of the diet in cases of tuberculosis of the lungs is still much discussed, but the surgical form shows very good results. Fistulas of soft parts discharge less after a short time, the discharge becomes more serous and finally ceases while the fistulas close. Figures 1 and 2 show tuberculosis of the fingers before and after dietary treatment which the patient received at Sauerbruch's clinic. Tuberculosis of bones reacts likewise. Swelling of joints is reduced and even severe joint cases with old fistulas were cured. It is important that patients over forty-five years of age who usually give an unfavorable prognosis are very much benefited by the diet. I remember a man

forty-eight years old with tuberculosis of the hip joint and mixed infected fistulas who was treated in Munich during the early stage of the dietetic studies. The man was completely cured after all other therapies had been tried in vain. In 1926 Krecke at a surgical meeting reported the case of a ten-year-old boy with tuberculosis of the small foot joints. He was cured after eight weeks. Of course, these cases are not incurable and usually get well after eight to ten months, but the diet shortens the illness considerably. Since then a great number of authors have reported favorable results in surgical tuberculosis. Today we are entitled to include certain kinds of tuberculosis of the lungs into the surgical field. Phthisis, the emaciating disease, certainly represents a special type of tuberculosis and we cannot expect the same results as in cases of tuberculosis of the hip joint. Especially lung specialists in sanatoriums do not share Hermannsdorfer's optimistic opinion and remain rather skeptical. But it can be safely stated that the diet brings a considerable number of far-advanced and so long inoperable cases into the stage where surgical treatment can be applied. When we consider that according to Sauerbruch's statistic 67 per cent of operated cases resume their work, the value and results of the diet should not be overlooked or underestimated.

It happens very often in experimental medicine that two authors disagree on the same subject, mostly because conditions for their experiments were different. Many things have to be considered when it comes to a diet. Sometimes the original rules are not followed. If the mineralogen is omitted or its substitutes changed, no great harm is done. But if three meals are given instead of seven I think one of the main points is neglected. It is evident that digestion and food value are largely increased by frequent meals consisting of smaller portions, much more so than by three ample feedings. Sometimes reports are given covering only a period of a few weeks. Needless to say no real opinion can be formed in such a short time. It takes about two weeks to get the patient used to the diet. There are only a few who cannot stand the lack of salt, but this part of the diet represents most of the technical difficulties and requires a well and specially trained dietitian. This diet cannot be prepared in the usual way, therefore a special nurse or cook will be necessary. The surgical clinic in Munich started to get good results only after a special dietitian from Bielefeld (Gerson's place) was obtained and put in charge of preparing the food.

To cover up the lack of salt is less difficult in America than in Europe, because here more substances are available to give the food good taste. The all-year-round selection of fresh vegetables and fruits present another great advantage. But still the rule stands that a well-trained person has to be responsible for the food preparation. In New York about eight nurses are specially trained for this diet and they should represent a nucleus for future development. This complicated diet easily introduces misunderstandings and consequently bad results. Here another point must be mentioned. It is wise and very helpful to isolate patients on this diet and have them well watched. I remember in Munich, that during the early stages of this diet patients were kept in the same building with others. Nobody suspected or watched their fellow patients or visitors. The results obtained then were far less favorable than later on with isolation and strict control of visitors. We must not forget the psychology of the patients and the good-hearted visitors who will supply additional food, misled by their feelings.

In the course of the experiment Hermannsdorfer and Gerson advised different types of food. To avoid complications in selecting the special diet I mention for various reasons Hermannsdorfer's last publication. The cook book he has published in the third edition seems to give the diet which best represents the results of Sauerbruch's and Hermannsdorfer's experiences.

OS INTERMETATARSEUM AND HALLUX VALGUS*

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THE interest which prompted this review of *x*-rays of feet in approximately 500 persons was initiated by the discovery of an os intermetatarseum in a foot with hallux valgus which was *x*-rayed preoperatively. In this case it seemed that such a bone might mechanically aid in the production of such a deformity. This has been suggested by Köhler as a cause contributory to hallux valgus. With this in mind all foot plates in the files of the Lakeside Hospital for the past five years were examined to learn if this bone, easily overlooked, were present in other cases of hallux valgus. Five hundred and twenty-one plates permitted the ascertainment of the degree of valgus and the absence or coincident presence of the os intermetatarseum demonstrable by *x*-ray. Forty-two other plates were of feet with ununited epiphyses and are not included in this series.

Those feet showing the presence of hallux valgus, as determined by the degree of angulation of the first metatarsal and the proximal first phalanx and by the displacement of the sesamoid bones, were roughly graded as moderate, severe and very severe valgus, it being taken into consideration that few so-called normal feet of those examined showed a perfect alignment of the metatarsal and phalangeal bones. With such a classification 26 per cent (138) of the feet, including 23 pairs with double valgus and one pair with unilateral valgus, were classified into 60 per cent (84) with moderate valgus, 30 per cent (42) with severe valgus, and 10 per cent (12) with a very severe valgus. In the total series, however, the os intermetatarseum was found but 24 times. In 63 per cent (15) valgus was associated with the os intermetatarseum. Thirty-seven per cent (9) of the cases with this bone present showed no evidence of valgus.

FIG. 1. Bipartite os intermetatarseum.

This leads one to believe that while the os intermetatarseum may produce some tendency to valgus, the latter is by no means always associated with the presence of this bone.

Conclusions may need to be somewhat tempered in the light of the findings of the anatomists who report an incidence for this bone of about 8 per cent, whereas we have been able by *x*-ray to demonstrate but 4.6 per cent. It may be that our failure to visualize it more frequently is due to its cartilaginous or poorly calcified nature. Such a presumption is in accordance with the findings of those who have made dissections. Many plates were classified as not showing this intermetatarsal bone when a poorly defined area of increased density was evident between the bases of the first and second metatarsals, because this is the region of the dorsalis pedis artery which might have cast shadows

* From the Department of Roentgenology, Lakeside Hospital. Submitted for publication November 2, 1931

such as those seen and which in some plates could be identified as a sclerosed vessel. Only those plates which were examined several times at distinct intervals and which gave strong evidence for the presence of this bone were recorded as showing the os intermetatarseum. Other larger and better calcified bones of the foot were noticed in an incidence very close in percentage to that reported by anatomists from their dissections.

Fig. 2. Bilateral os intermetatarseum.

In this series with 26 per cent (138) of the plates demonstrating valgus, but 2.8 per cent (15) show in association with the valgus an os intermetatarseum, which has been suggested as a contributory cause of valgus. The additional fact that 37 per cent (9) of these feet with os intermetatarseum do not show valgus makes one feel that no great stress should be laid on this accessory bone as a contributory cause of foot deformity. Of those feet showing coincidental appearance of os intermetatarseum and hallux, 53 per cent (8) were grouped as moderate, 25 per cent (6) as severe, and 7 per cent (1) as very severe. Therefore, in addition to a frequent lack of association of valgus and os intermetatarseum, we may further say that the presence of an os intermetatarseum in a foot with valgus does not seem to make the degree of deformity unusually severe.

Two of the variations of os intermetatarseum reported by anatomists, but very uncommon in *x*-ray literature, were noted. They are fusion of the os intermetatarseum with the first cuneiform and fusion with the first metatarsal. A bipartite os intermetatarseum was discovered (Fig. 1). No previous report of a bipartite os intermetatarseum has been found in the literature. In 2 cases (4 plates) of 24 plates the os intermetatarseum was found to be present bilaterally. Köhler reports having seen one such case. In one pair there was associated a severe and a very severe hallux valgus. (Fig. 2.)

CONCLUSIONS

1. There is little evidence for the so intermetatarseum's contributing to either the presence or the degree of severity of hallux valgus.

2. A case of bipartite os intermetatarseum, hitherto unreported, is demonstrated.

3. Two cases of bilateral os intermetatarseum are reported.

[For References see p. 344.]

NEW INSTRUMENTS

THE BRUNET-FLAGGE NEEDLE DRIER

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HIGH POINT, N. C.

TO date all attempts to dry hypodermic needles and like instruments satisfactorily have failed or have been too time-consuming to be practical. A persistent effort in this direction is conclusive evidence of the desirability of an instrument designed to accomplish this end.

When the needle is attached to the Luer syringe, a dead space is left, for mechanical reasons, between the extreme end of the Luer syringe slip and the inner end of the needle conus. This space always retains a portion of either the medication, cleansing or sterilizing fluid, and is not dried with any of the needle driers. Regardless of the kind of steel used in making the needle, or the character of the sterilizing fluid, ultimate destruction of the metal or occlusion of the lumen is the final result.

The importance of a clean needle free of erosion or a nidus of foreign material in any part of the shoulder or needle is appreciated by every user of hypodermic medications. Especially is this true in laboratory or intravenous work. Nothing is more exasperating or embarrassing than to have a needle in a vein blocked by a rapidly formed blood clot or an eroded surface either in the shoulder or the inside of the needle.

To overcome this defect in the construction of all driers on the market the form here described was designed. The improvement over all other driers consists in a provision whereby a backward flow of air effectually dries the shoulder and the inside at the same time. This backward flow of air is induced by grooves cut in the Luer tip of the drier which, together with the inner surface of the hub of the needle,

FIG. 1.

form channels which permit both a backward and a forward flow of air, thus drying the dead space at the end of the Luer tip and the inside of the needle at the same time.

The illustration shows how the air may be provided by a rubber bulb fitted on the stepped shoulders of the drier. A dry piston syringe may be substituted for the rubber bulb by changing the construction of the drier to fit the nipple of the syringe.

In practice the drying is effected by throwing over the end of the needle and hub a piece of gauze which catches the droplets and prevents them from being sucked back into the needle as the bulb expands. A few quick thrusts of air are sufficient to dry the needle and leave it with a clean surface.

This drier is small enough to be enclosed in the usual hypodermic unit.

Until such time as needles become so cheap that they may be discarded after a single service, this simple device will pay for itself many times in the course of a year.

A NEW TOURNIQUET*

H. DAWSON FURNISS, M.D., F.A.C.S.

NEW YORK

THE tourniquet here illustrated has been used by me, and friends to whom I have given it, for several months with the greatest satisfaction. It consists of two metal parts and a strip of cotton elastic, ¾ inch wide and 18 inches long. The friction portion, that on the right, is hooked over the tongue-like part of the other metal piece. By traction on the free end of the elastic any desired degree of tension may be obtained. To relieve tension the round metal tab is lifted lightly toward the left, which allows the elastic to run through the friction portion. It has the advantage of allowing tension to be increased evenly, without jar, and either slowly or rapidly. It is much more comfortable than rubber tubing, and there is less chance of pinching the skin.

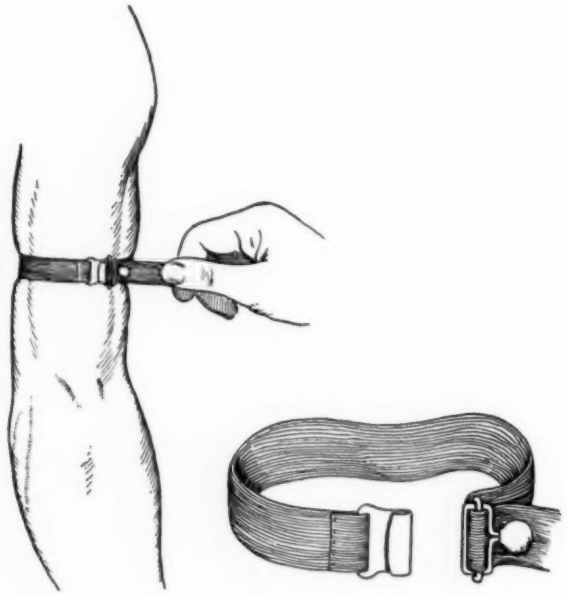

FIG. 1.

The device, originally intended for holding papers, attracted my attention at the Business Show. To make the tourniquet, the only change necessary was to substitute elastic for the webbing.

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*Continued from p. 342.

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EDITORIALS

MEDICAL ECONOMICS

THESE are days when a majority of physicians have an interest in the economics of medicine. Ways and means of balancing the budget are favorite subjects in hospital board discussions. At a recent conference of hospital superintendents the presiding officer asked those present to raise their hands if the hospital they conducted had met expenses during their last fiscal year. The response was less than 5 per cent. We do know the physician has been no exception in that his income has suffered a marked reduction. Following the financial trend his real estate holdings have decreased in value and his savings in the form of stocks and bonds have almost reached the melting point. Yet there has been no complaint. The man engaged in business or on a salary wails about his cut in pay but, for the most part, the physician has remained silent. That he has been and is financially affected is no secret.

At a medical gathering this topic casually crept into the discussion. Part of the talks were devoted to certain abuses. One was that the law should be changed to read that only American citizens or those who have legally signified their intention of becoming citizens be granted a license to practice medicine. It was pointed out that we permitted anyone who could pass a State Board examination to practice. Inasmuch as economic conditions in foreign

countries are very bad and as this country is looked upon as a land of gold and milk and honey, in spite of our economic upheaval, all who can reach our shores do so, and shortly are in competition with our medical citizens. Needless to say all did not subscribe to this reasoning. Another of the group suggested that only graduates of medical schools in this country be permitted to practice. Stories were told of American physicians who went to France during the war, married French girls, decided to remain and practice and did so, after they had spent another four years studying medicine in France. To this view there were dissenting opinions. Another gentleman attacked what he called "the visiting teacher racket." A physician from a foreign clime, usually of more than the usual attainments, finding it hard to make ends meet in his mother country, by various means gets invited to this country to give a course of lectures in one of our medical schools. He arrives with great fanfare and flourish of trumpets. Usually he is well press-agented. He gives a few lectures and talks before medical groups and lay organizations. Meanwhile, he opens an office and for eight or nine months of the year engages in active practice, assiduously devoting himself to making money. Being connected with a teaching institution he is not required to pass a State Board examination (at least, this is true in New York State). It was conceded that it was fair and proper for any foreign physician to come here and lecture, but that he should give his lectures, be paid for giving them, and then call it a day. However, as one of the group said, "Only a few are invited so why even consider the subject?" The matter of free and part pay clinics came up in the discussion, but this is an ancient topic and needs no further mention.

Naturally, nothing was settled. Out of it one would conclude that many physicians know or feel something is wrong with our economic structure but look to the other fellow to correct the faults that affect their means of making a livelihood.

We are interested in learning your opinions concerning these problems. It may be you harbor resentment about many things we have not mentioned. You may think all is well with us and that the future is secure. Perhaps you agree with the advice, once given, "Stick to your task, do good work, and the income will take care of itself."

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CORRESPONDENCE

To the Editor:

Your article in the August number of THE AMERICAN JOURNAL OF SURGERY concerning Dr. John Fleet was of particular interest to me. I happen to be descended from John Fleet's sister. I know of no portrait in our branch of the family of John Fleet. He had a nephew, John Fleet Eliot, who died in Boston about 1885 and left his manuscripts and papers to the Massachusetts Historical Society. If he had a portrait of him it would be found in the archives of that Society.

There are in the possession of my Mother two leather fire buckets that belonged to Dr. John Fleet. At that time every citizen in the city of Boston was required to have in his front hall two fire buckets and was required to answer all fire alarms. I am sending you a photograph of these buckets, which I thought might be of interest to you.

FIG. 1. Fire buckets which belonged to Dr. John Fleet of Boston (1766–1813), now in possession of his great-niece, Mrs. Katherine Alden, Los Angeles.

ELIOT ALDEN, M.D.

Hollywood, Calif.
August 22, 1932.

AMERICAN PHYSICIANS

JOHN REDMAN COXE

JOHN REDMAN COXE, born in New Jersey in 1773, received his education in Philadelphia under his grandfather's care, until, at the age of ten years, he was sent to England, where he resided for seven years. He completed his classical education in Edinburgh, where he also attended a course of medical lectures at the university.

Returning to America in 1790, he studied medicine under Dr. Rush. He graduated from the University of Pennsylvania, after which he again went to Europe and visited the hospitals of London. Later he studied in Edinburgh and Paris. In 1797 he again returned to Philadelphia, where he began to practice. He became one of the resident physicians of Bush Hill Hospital, under the charge of Drs. Physick and Cathrall. He was appointed physician to the Port of Philadelphia in 1798, and to the chair of Chemistry in the Medical Department of the University of Pennsylvania. In 1819 he was transferred to the chair of Materia Medica and Pharmacy. He was elected to the medical staff of the Pennsylvania Hospital in 1802.

Dr. Coxe was at one time the editor of the *Medical Museum*. He published as editor "The American Dispensary," in 1808, a medical dictionary, "Exposition of the Works of Hippocrates," and an "Essay on the Origin of the Discovery of the Circulation of the Blood."

Dr. Coxe was an advocate of vaccination. This was illustrated by the fact that he vaccinated his child, then an infant, "at a time when the full efficacy of the practice was still in suspense in the public mind. He fully tested it, by exposing him [the child] to the influence of the smallpox after vaccination; the result of this bold experiment contributed to establish reliance in the protective power of vaccination."

He died March 22, 1864, at the age of ninety-one years.

T. S. W.

[From Fernelius' Universa Medicina, Geneva, 1679.]

BOOKSHELF BROWSING

THE ROLE OF EXPERIMENTS ON ANIMALS IN THE TREATMENT OF DISEASE*

CONTROL OF ANIMAL DISEASES

VERANUS A. MOORE

ITHACA, N. Y.

A GENERATION has passed since the experimental method was introduced into the study of microorganisms in their relation to disease by Pasteur and his compeers. It has been referred to as the "new pathology" because it associated intimately the causative factor and the tissue changes. It is not too much to claim that since the application of this method the results obtained have done more than all the observations of preceding centuries to raise human knowledge of animal diseases from "conditions of vagueness to conditions of exactness." The benefits derived from researches, since the adoption of the experimental method, can be understood only by comparing them with the results obtained by other methods in earlier times.

It is difficult to visualize the situation that existed seventy and more years ago when communicable diseases often decimated flocks and herds; when their cause and means of dissemination were shrouded in mystery; when the frantic efforts of owners to save their animals from merciless plagues were useless; and when medical sciences were as ineffective in explaining the cause of the diseases as the owners were in controlling them. In addition to the physical suffering of animals, there is the financial loss which not infrequently brings privation and want to many people. When animals that constitute the chief source of income in a community are destroyed by disease, the consequences become a matter of much public concern.

Data are incomplete on the extent of losses caused by infectious and epizootic diseases prior to the introduction of the theory of a specific etiology for the plagues of man and beast. Up to that time the cause of communicable diseases was believed to be outside the power of man to control. As a result, these maladies were allowed to spread according to the laws that govern their dissemination. A distinguished English veterinarian placed the losses of his country from 1839 to 1870, inclusive, due to rinderpest and contagious pleuropneumonia of cattle alone, at $400,000,000. It was the terrible havoc wrought by these diseases in Germany that prompted the establishment of the *Tierärztlichen Hochschule* in Berlin in 1790, with the objective of finding some way of stopping their

* This is the seventh of a series of articles on the value of animal experimentation in medical progress. The next article will appear in an early issue.

ravages. In America, communicable diseases of live stock were beginning to appear in serious proportions at the time the Land Grant colleges were founded in 1862. It was one of their functions to investigate animal diseases. Today all but one of the eleven veterinary colleges in the United States are integral parts of state or Land Grant colleges, and the one exception is a school in an endowed university. The Federal Bureau of Animal Industry was established in 1884, for the specific purpose of officially combatting epizootics, and later state live stock sanitary boards were created. The function of these organizations was to study and control the communicable diseases of animals which threatened the animal husbandry of the country.

There are several diseases of live stock in the United States that formerly exacted annually a toll of many millions of dollars worth of animals which in recent years have been brought under almost complete subjugation. When owners become more familiar with the nature of these diseases and with what modern research has taught can be done to prevent them, the damage which they occasion will be reduced to a minimum. There are two important factors involved in the eradication of these maladies; namely, more definite knowledge of their nature, that can be attained only by continuous researches and experimentation, and the application of the knowledge acquired which requires further education of the agricultural population along these lines.

An understanding of the functions of the body and its nutrition has been the basis of successful methods for improving the care and handling of animals. This is not restricted to their physical comfort, in the surroundings in which they must exist, but it applies equally to their productiveness. It is natural that those interested in the improvement and higher development of animal husbandry and the industries depending on it should desire, not only to retain the advantage they have acquired already, but to increase the benefits through further researches and study. As the conditions under which animals are kept vary, so the diseases from which they suffer undergo appreciable changes. This means that to safeguard animal husbandry, which is the greatest industry in agriculture, the new and constantly changing problems associated with it require renewed and continuous study.

Further objectives in animal experimentation are to ascertain additional facts concerning their physical requirements whereby the methods of handling them may be improved in such a way that better health may be insured and untimely death from disease prevented. One need but glance at the methods of handling farm animals a century ago and then witness the conditions under which they are kept today to appreciate the improvements that have accrued from the experiments that have been made on subjects pertaining to sanitary and otherwise healthy abiding places for farm animals. Further, their productiveness has been increased tremendously. The average quantity of milk per cow in dairy herds has been increased nearly, if not quite, 100 per cent. Again, better knowledge of the conditions responsible for the general diseases among animals points to more efficient methods of preventing them. Methods that are successful in controlling epizootic and other infectious diseases are, without exception, based on facts obtained from experimental work, and by no other means.

At times the diagnosis of an infectious disease requires the use of animals. Some years ago a disease appeared among the cattle in a number of herds in northern New York that resembled foot and mouth disease, and which was declared by some people to be such. The accuracy of the diagnosis was in doubt. The live stock sanitary officials were forced either to accept the diagnosis and destroy all of the animals on the farms where the trouble existed and indemnify the owners; or prove that it was not foot and mouth

disease. The experimental method was applied. Several healthy calves that had not been exposed were inoculated from the infected animals and the trouble was found to be a form of inflammation of the mouth and not foot and mouth disease. This simple experiment settled the points at issue in the diagnosis, saved the State from the stigma of having to record again the appearance of that disease, and saved the animals for their owners.

The extent of the losses formerly sustained from communicable diseases among animals is not recorded. It is known, however, that soon after the introduction of the experimental method the federal government estimated the loss in the United States from these causes to exceed $200,000,000 annually. The history of several of the more destructive diseases shows that they baffled all attempts at prevention until their specific nature was determined. Following the discovery of the cause of anthrax by Pollander, of tuberculosis by Koch, of glanders by Loeffler and Schutz, of septicemia hemorrhagica by Kitt, of Texas fever (southern cattle fever) by Smith, of infectious abortion in cattle by Bang and of hog cholera by de Schweinitz, a large amount of work was initiated to ascertain how each of these and other diseases were disseminated and by what methods they could be prevented. Where there are competent veterinarians, and live stock sanitary officers animal husbandry is protected against serious losses from these maladies. The great live stock industries of this country exist because of the application of knowledge obtained from carefully conducted experiments on the nature of the particular diseases that threatened their existence. Without this knowledge, the control of the great scourges of animals, like anthrax, contagious pleuropneumonia, foot and mouth disease, hog cholera, rabies, Texas fever, and many others, would be impossible.

The stabilization of animal husbandry, and the industries dependent on it, is due very largely to the control of infectious and epizootic diseases that for centuries barred its progress. The success attained is due to results of experimental work. To understand fully what this method means by way of elucidating the nature of disease, as well as exemplifying the economic significance involved, one must have a clear perspective of the individual results of research that have been obtained. A brief summary of the history of the more important infectious diseases of live stock will portray more clearly, perhaps, than any other statement our indebtedness to the experimental method.

ANTHRAX

Anthrax has been known since very early times. It figures largely in the history of the early and middle ages as "a devastating pestilence attacking animals and through them mankind." Primarily it is a scourge of cattle and sheep, but often of other animals and man. Cruickshank states that it caused annually the death of fully 500 people among the wool sorters in London. Prior to the discovery of its cause thousands of sheep and cattle died of it each year. When its nature was revealed, the means by which it spread determined, and a vaccine produced, its ravages were checked. The method of vaccination, introduced by Pasteur, removed largely the dread of it from the mind of cattle and sheep owners of France. There is a no more spectacular event in medical history than the experiments made by Pasteur at Pouilly-le-Fort in demonstrating the efficiency of his vaccine to immunize cattle and sheep against anthrax. Not one of the vaccinated animals developed the disease after exposure, while all of the controls died. The vaccine enabled farmers to keep live stock in many places where otherwise it would not have been possible because of the prevalence of anthrax spores in the soil. This was especially true of large sections of France, Germany and Spain. Chester, at the Delaware Experiment Station, prepared a vaccine against anthrax that made it

possible to utilize for grazing lowlands along the Delaware River that previously could not be used because of heavy anthrax infection.

In 1899, Sobernheim discovered a method of vaccination consisting of an injection of anthrax bacilli with a quantity of immune serum. This is known as the simultaneous method, and it was, and still is, employed extensively by sheep raisers in South America. It is reported to be giving excellent results. Eichhorn states that immune serum is not only a valuable prophylactic against anthrax in animals, but an efficient therapeutic agent for the disease in humans. This is confirmed by a number of physicians who emphasize its value as a remedial agent. Pellon reported 205 cases among the industrial workers and their families in Marseilles, with but 25 fatal cases. The pronounced low mortality is attributed by him to the use of anti-anthrax serum. Jacobson has published on account of 61 cases in New York City that occurred from 1914 to 1923 of which 23 were caused by infection from shaving brushes.

Anthrax bacteria have been brought to many places in the United States with infected hides, wool and hair. Were it not for the preventive measures that are being applied wherever and whenever it appears, anthrax would soon become a serious menace to the sheep and dairy industries of the country. This is illustrated by outbreaks that have occurred at different times during the last fifty years. In 1906, it appeared in northern New York and spread to the animals on eighty-four farms. There were 170 fatal cases before the 3000, or more, animals in the locality could be immunized by vaccination. When that was accomplished, the disease disappeared. Since that time, it has been kept under perfect control by means of vaccination.

Further, anthrax is a menace to human life. The records show that there are approximately 130 cases in the United States annually. It is an achievement of much significance that a serum has been made with high therapeutic value that is reducing the mortality from a very high to a very low percentage. The proper use of vaccine and serum as prophylactics is decreasing steadily the number of outbreaks among animals which means a smaller number of human cases. The chief sources of human infection are diseased animals and infected wool and hair that are handled, and shaving and other brushes manufactured from bristles or hair that came from anthrax diseased animals.

The preparation of anthrax serum, testing the efficiency of the vaccines and making diagnoses, require the use of a few horses and experimental animals, but anthrax is no longer a serious menace. Many American farmers who live in infected areas have become so thoroughly accustomed to the prophylactic use of vaccines that they apply them as a recognized part of their routine operations. In this way thousands of acres of infected land are utilized for grazing purposes that otherwise would be idle. The only disease of animals, worthy of mention by the classical writers and the supposed murrain of the Book of Exodus has been brought under control by patient, painstaking experimentation.

CONTAGIOUS PLEUROPNEUMONIA OF CATTLE

Contagious pleuropneumonia originated in the highlands of Central Europe. It spread to every cattle-raising country in the world. It was estimated that during the first quarter of the nineteenth century it cost England and her colonies $450,000,000 in deaths alone. It was brought to the United States in 1843 in a cow imported directly from Europe and taken from shipboard to a Brooklyn cattle shed. Because there was little traffic in cattle, it spread slowly in the beginning. In a few years, however, it became widely disseminated in the Atlantic states. By 1880, it was evident to those most familiar with it that if it were not eradicated it

might, and very likely would, through some one of the increasing avenues of transportation, reach the cattle on the western ranges, where its control would be especially difficult, if not impossible. An important industry was threatened with impairment, if not extinction. Beef and dairy products, valuable and highly prized foods, seemed on the verge of soaring in price to heights unattainable by common people.

Why should a plague of this kind destroy our cattle and ruin the beef and dairy industries of the country? We were ignorant of its nature and knew not how to prevent its spread. In 1851, experiments at Pomeraye, and other places in France, made under a commission appointed by the Government, had demonstrated its infectious nature. They showed beyond question that it would spread from diseased to healthy cattle. The idea of a specific etiology had not been accepted generally. It was necessary in the circumstances, owing to popular skepticism, to repeat the experiments to convince the doubting public. This was particularly true in the United States. The American mind demanded additional evidence of its contagiousness before drastic measures for its eradication could receive approval. The work of Salmon, added to the results of the French investigators, furnished evidence of its infectiousness which made it desirable for Congress to authorize the organization of the Bureau of Animal Industry in the U. S. Department of Agriculture to carry out rigid measures for its complete eradication. As a result every trace of the disease was removed from the United States within seven years after a definite method of procedure was adopted, and at a cost ($1,609,000.72) that was trifling in comparison with the losses that would have occurred annually had it become permanently established as a plague of American cattle. It was the convincing evidence obtained from actual experimental work that made it possible to protect at that time the dairy and beef industries of the country against one of the most destructive diseases of cattle.

GLANDERS

Glanders is among the oldest equine diseases known. The ancients described it and recorded extensive losses it occasioned. Many theories prevailed concerning its cause, the most common being that it spread in some unknown way through the air. The importance of its presence is illustrated from the report of losses caused by it in Prussia where in ten years, from 1876 to 1886, it destroyed 20,566 horses. In the large cities of this country it became a veritable scourge. In 1882, Loeffler and Schutz discovered its specific organism which they were able to cultivate in pure culture. They found it escaped with the nasal discharges of infected horses and that well ones coming in contact with this material were infected. A further victory was the discovery of mallein. By its use infected animals could be detected that failed to exhibit symptoms.

Glanders, like anthrax, is communicable to man, and already a large number of human cases have been reported among those who had the care of, or employed, glandered horses. Since the introduction of mallein, the enforcement of sanitary regulations, and complete isolation or destruction of infected horses, glanders has been reduced greatly. In 1906, Robbins, of the Royal Victoria Hospital in Montreal, reported 156 cases in man. In the human species it has a very high mortality.

In the United States, glanders still prevails in certain rural districts. In other countries where automobiles are less abundant, it is a serious menace to the equine species. The horrors of strangles in countries where scientific methods for its control are not practiced, are illustrated in a report in a Soviet Red Gazette, quoted by Hobday where 117 children were destroyed because they had glanders. They broke down the sanitary requirements to prevent the disease in horses and

then shot their children when they became infected.

RABIES, OR HYDROPHOBIA

Among the diseases of man none are dreaded more, and in animals, few, if any, are more pitiable than rabies. There is no longer disagreement as to the existence and dangerous nature of this disease. It is also known that it is readily communicated from rabid dogs to healthy animals and people. With many infectious diseases the specific organism has been isolated and cultivated on artificial media. This is not true with rabies. Pasteur, by a long series of experiments, showed that the specific cause, whatever it is, was localized in the central nervous system of the diseased individual. In 1884, he demonstrated that immunity could be conferred by the use of an attenuated, fixed virus which he had been able to produce by the use of animals. Concerning his first use of the attenuated virus in man, Pasteur wrote:

> Making use of this method I had already made fifty dogs of various races and ages immune to rabies and had not met with a single failure, when on July 6th, quite unexpectedly, three persons, residents of Alsace, presented themselves at my laboratory. One of these, a boy of nine years, who had been bitten in fourteen different places by a rabid dog, was saved.

The total mortality among the first 9433 people treated was 0.161 per cent. In 1890, among 415 persons who were bitten by rabid dogs, and who took the Pasteur treatment, there was not a single death. Tens of thousands of people have taken the treatment with very few failures. In 1921, Sellers, Director of the Georgia State Board of Health Laboratories, found that rabies existed in 29 states and that a total of 5558 heads had been examined in official laboratories, and that 2690 of them were positive. Further he learned that there had been 168 cases of rabies in man from 1917 to 1921.

In 1903, Negri, of the University of Parva, described structures in the cytoplasm of brain cells of rabid animals that he suspected to be of etiological value. A few workers have arrived at the same conclusions. Others have considered these bodies to be specific degenerations. Kraus, Guerlac and Schweinberg, in their recent volume on Lyssa, place emphasis on the value of Negri bodies in the diagnosis of the disease. They are recognized as indicative of rabies in all diagnostic laboratories.

While rabies is a much dreaded disease among dogs and in the human family, it is frequently the cause of heavy losses among food-producing animals. Not long since the State Veterinarian of Wisconsin reported that in one year rabies had caused the death in that state alone of 400 cattle, 100 hogs, 56 horses and 28 sheep. In a single county in Central New York it was estimated by an official that rabies caused the death of $4,000 worth of farm animals in a single year. As rabies is transmitted from infected to healthy individuals by direct inoculation, or bites from rabid animals, and as the dog is the only animal in domestication that has a tendency to bite, the control of the disease in canines will circumscribe its ravages in other animals and in man. To accomplish this a large amount of work has been done to produce a single dose vaccine for immunizing dogs. Much progress has been made. Those engaged in the work are very optimistic that an efficient method will be forthcoming. Already the experimental work on rabies has localized its virus, shown how it is disseminated and given us effective methods for preventing the disease in people who have been exposed. These methods are equally applicable to domesticated animals, but as yet they are too expensive to be practicable.

SWINE DISEASES

The most important infectious disease of swine in the United States is hog cholera. The first recorded epizootic in

this country occurred in Ohio in 1833. It spread gradually until it became a menace to the swine industry. De Schweinitz estimated that the losses from this disease alone in one state was $15,000,000 annually. A disease supposed to have been introduced from Europe about 1830 had become a widespread and unquestioned plague by 1880. In 1903, De Schweinitz found that in the blood of swine affected with hog cholera there was a virus that would pass through a Berkefeld filter. Continued investigations in the Bureau of Animal Industry, and elsewhere, showed that swine could be immunized against this disease by the use of serum from hyperimmunized pigs. The result of this discovery has led several states to manufacture serum for the purpose of immunization. The saving from suffering and death in swine and the gain to the pork industry of the country, resulting from this work, is enormous. No one who has witnessed the loss of hogs in outbreaks of cholera can fail to appreciate the great blessing that has come to this species of animals by bringing this disease under control.

Swine plague, or *septicemia hemorrhagica*, is quite prevalent and a serum has been prepared that is reported to give excellent results in its treatment. *Swine erysipelas*, which has been a scourge of swine in certain parts of Europe, has recently been reported in this country. European observers have found human cases of infection with the organism of swine erysipelas. The symptoms are a slowly advancing, erythema-like rash, and often joint complications. Endocarditis often supervenes. Edel suggests that Rosenbach's erysipeloid is identical with the swine erysipelas as determined from the clinical, therapeutic and epidemiological aspects. Fortunately, the immunizing serum developed by Lorenz for the treatment of this disease in swine has been found to be efficient in the human subject. While at present it is rare in this country, its prevalence in Europe renders exceedingly important the production of an efficient serum.

TEXAS OR SOUTHERN CATTLE FEVER

Texas fever has been described as "bovine malaria." It has been known to exist for a great many years in the South. It frequently gained entrance to the northern states where it caused the death of many native cattle.

The cause of Texas fever was a mystery until the experiments begun in 1889 by Smith, showed it to be a protozoan, and that it was transmitted from the infected to well cattle by means of a tick (*Margaropus bovis*). It has been demonstrated repeatedly on cattle that the tick is the carrier of the virus; that in the absence of this species of tick, southern cattle can be shipped north at any time of the year with perfect safety to the native cattle; and that if the ticks are removed from the pastures in the South, northern cattle can live on them without becoming infected. These experiments led to the conclusion that the most effective manner of eliminating this destructive disease was to eradicate the cattle tick from the South. Already this has been done for large areas in the southern states with the result that the dairy industry has been improved greatly. A further and more important bearing of this discovery is that the virus of a specific disease is transmitted by an insect. This has been of great significance in the control of protozoan diseases in man that are transmitted by mosquitoes and other insects.

INFECTIOUS ABORTION IN CATTLE

For many years dairy cattle have suffered from infectious abortion which in many instances has been so extensive that the maintenance of the herd was impossible. The losses caused by it have been estimated, by the Chief of the Federal Bureau of Animal Industry, at from $20,000,000 to $30,000,000 annually. In 1897, Bang discovered its specific cause, and since that time experiments have been conducted in many countries to determine its nature and means of dissemination. Growing

out of these studies a definite method of procedure has been formulated whereby it is possible for breeders to eliminate it from their herds.

In 1918, Evans pointed out the very close relation between the cause of this disease and that of Malta fever. The similarity of the morbid conditions in goats produced by *Brucella melitensis* and that in cattle due to *Brucella abortus* is in itself suggestive that *Brucella abortus* may possess pathogenic properties for the human subject.

In 1924, Kieffer reported a case of human infection with *Brucella abortus*. The clinical picture indicated Malta fever, but the organism obtained from the blood was identified as *Brucella abortus*. DeKrote reported a case of undulant fever in a man who became infected by removing the placenta from a cow that had aborted. Duncan reports a like case in a butcher who was a heavy drinker of raw milk. Orpin found in Rhodesia an undulant fever due to the same cause. Carpenter has reported several human cases. In the last three years many reports of human infection with an organism indistinguishable from *Brucella abortus* have been made, not only in New York, but throughout the country. The investigations in connection with these cases are pointing to the fact that milk from cows that have aborted and whose udders harbor the infecting organism, may transmit it to the human subject, and that many cases of heretofore undiagnosed fever of an undulant type are caused by this infection.

Studies have been made in a large number of herds on the milk of cows that have aborted with the result that about 40 per cent of the udders of cows that actually abort harbor the organism. These experiments indicate that the safety of milk coming from herds in which this disease exists depends on pasteurization. Since July 30, 1930, all milk in California to be certified must come from cows that are free from the Bang abortion infection as well as tuberculosis. Were it not for the fact that it has been possible to use experimental animals and pregnant cattle in these investigations, the definite facts regarding the infectiousness of the milk would not have been determined.

OTHER DISEASES

In addition to the specific diseases, there are numerous parasitic infestations that cause extensive losses in all species of animals. The studies that have had for their object the ascertaining of the life history of parasites and the effect of certain drugs and chemicals on them when administered to their hosts, have made it possible, within certain limits, to control parasitism. Animal owners are indebted for their success in keeping their animals as free as they do from parasites to many long and trying investigations.

We have been dealing with the specific diseases and parasitisms. There is another field where experimentation has been productive of unmeasured benefits to animal owners. I refer to the extensive work that has been carried on in testing out the value of certain minerals in food stuffs, the effect of certain light rays on maintaining health; and the discovery of vitamins and their functions. Never before in the history of agriculture have farm animals been better nourished than at this time. Many painful disorders have been corrected through the use of proper diet. These benefits could not have come to domesticated animals had the opportunity to make long series of experiments been denied.

I have sketched in a very fragmentary manner but a part of the advantages that have come to comparative pathology and the benefits that have accrued to animal owners from the work that was started by Pasteur and his co-workers. This has stimulated greater efforts in experimental physiology from which knowledge of untold value has been acquired. In view of all that has been done, we are reminded, by some new discovery, almost daily that practical preventive medicine is in its

infancy. Many fertile fields for research are not yet entered and in none are the results final.

The demands for further investigation were never more pressing than they are today, and never before was there more interest in research. If the work should be checked, progress in animal husbandry would be doomed, and the problems associated with animal diseases would remain unsolved. The experience in this country would be like that in Great Britain, where, by parliamentary enactment, animal experimentation was so crippled that the country which should have done the most, by virtue of her wide geographic possessions and vast live stock interests, for improving methods of prevention and control of infectious diseases, has done very little. I quote from one of England's foremost veterinarians in a plea for animal experimentation:

> No country in Europe has, possibly, sustained greater loss during the last thirty-five years than our own; yet no country, perhaps, should have suffered less. With the finest breed of horses, and the most magnificent herds and flocks in the world, and a teeming population, whose health and wealth are largely centered in these, we have entirely neglected to protect them from the ravages of disease of home and foreign origin, by forgetting to foster and encourage that science which alone can accomplish this. That neglect has cost Great Britain and her colonies untold millions.[1]

[1] Fleming, G.: The Contagious Diseases of Animals; Their Influence on the Wealth and Health of the Nation, and How They are to be Combated.

BOOK REVIEWS

ARTERIOGRAPHIE DES MEMBRES ET DE L'AORTA ABDOMINALE (Arteriography of the Extremities and of the Abdominal Aorta). By Reynaldo Dos Santos, Professor to the Faculty of Medicine of Lisbon and Surgeon of the Hospitals; A. C. Lamas, Surgeon, and J. P. Caldas, Radiologist of the Hospitals of Lisbon. With a preface by Professor Leriche. Paris: Masson et Cie, 1931.

As Prof. Leriche says in the preface, here we have a beautiful book, full of original ideas, facts with a minimum of commentary, revealing new, almost undreamed of aspects of radiological investigation, a revelation likely to upset some of our present-day conceptions.

At first thought, the idea of puncturing the aorta or the larger arteries brings up visions of catastrophe, and yet, after all our work in safe use of ventriculography, in the injection of lipiodol in the spinal canal and in the tubes, is it really so revolutionary to inject into the arterial system an opaque substance which is rapidly eliminated?

The authors used abrodil or uroselectan B which is very stable and especially very soluble, thus permitting a greater opacity. Injected into the blood, it traverses the vessels as rapidly as the blood-stream, so that the radiography must be done during the injection. But the interesting story of this work is too long to relate in a review. The authors discuss fully the dangers, technique of injection, the radiographic technique. One fact deserves mention: the pain accompanying the injection of abrodil requires anesthesia—general for the upper extremities, general or spinal for the lower extremities. The authors have tried arterial anesthesia after Goyanes but not with satisfactory results. Later work with thorotrast seems to indicate it is a better medium and not painful. The radioactivity of thorotrast is so slight that no harm need be feared from that source.

The lesions in which the method has proved useful are as follows:

1. Arterial diseases: gangrene, aneurysm, ligations and resections, Volkmann's paralysis.

2. Osteomyelitis and osteoarthritis (tuberculosis and syphilis of bone, etc.).

3. Tumors of bone and of soft tissues. Of great interest are the illustrations of cases of tuberculosis of the knee and ankle joints.

For aortography the authors use uroselectan B, thus visualizing abdominal aortic aneurysms, hydatids of the liver, pelvic tumors, malarial spleen, and especially cases of nephritis, pyonephrosis and renal tuberculosis, and the demonstration of the abnormal vessels causing ureteral obstruction in certain cases of hydronephrosis. The authors' series include more than 300 cases of aortography.

HOW TO LIVE, Rules for Healthful Living Based on Modern Science. Authorized by and Prepared in Collaboration with the Hygiene Reference Board of the Life Extension Institute. By Irving Fisher, LL.D., and Eugene Fisk, M.D. Ed. 19, Completely Revised. N. Y., Funk & Wagnalls Co., 1932.

The nineteenth edition of this book, brought entirely up-to-date, is as full of meat as ever. Many physicians will undoubtedly disagree with some of the diets contained in the book but, all in all, the book is full of common sense, is practical and worth while. It is easy reading and its handsome flexible binding makes it an attractive book.

CLASSIC DESCRIPTIONS OF DISEASE. By Ralph H. Major, M.D., Springfield, Ill., Charles C. Thomas Co., 1932.

Over 300 selections of original general discussion with 127 illustrations and biographical sketches of the authors making an interesting anthology. Neither the reviewer nor anyone else would have made exactly the same selections. It is easy to criticize any anthology on the basis of both inclusion and exclusion. However, it must be admitted that the author has done his job well and little, if any, objection can be taken to the inclusion of the splendid pages he has selected from the works of the great medical authors from Hippocrates through Mackenzie. His biographies are concise, well written and informative. The selections included are entirely from the realm of internal diseases and it would be interesting to have a similar volume on surgery.

A Descriptive Atlas of Radiographs, An Aid to Modern Clinical Methods. By A. P. Bertwistle, M.B., CH.B., F.R.C.S. Ed. 2, Revised and Enlarged, St. Louis, C. V. Mosby Co., 1932.

This is the second edition of this work with 767 radiographs collected from various sources. The leading English physicians have contributed to the volume. The text consists of descriptions of the radiographs with short chapters on Radio-Diagnosis, The Clinical Application of Radiology, and Milestones in Radio-Diagnosis. This book may be a handy work of reference for the tyro but we believe the more experienced man may find it necessary to have more complete monographs covering the various chapters.

The subjects covered are: Normal Bones and Epiphyses, Congenital Abnormalities, Fractures, Inflammation of Bones, Tumours of Bone, Injuries and Diseases of Joints, Nasal System, Alimentary System, Urinary System, Respiratory System, Nervous System, Vascular System, Thyroid System, Female Generative System and Muscles. In attempting to cover such a field in a volume of 550 pages, many loopholes are to be found.

As far as it goes, the work has been well done but it is felt that it is too sketchy to be recommended as a practical reference work.

Fungous Diseases, A Clinico-Mycological Text. By Harry P. Jacobson, M.D., With Introductions by Jay Frank Schamberg, M.D. and Howard Morrow, M.D. Springfield, Ill., Charles C. Thomas Co., 1932.

As Dr. Schamberg points out in his Introduction, "While there is still much to be learned with regard to many points in connection with the life-history of the diseases described, a great mass of clinical and laboratory facts have already been garnered, and these are most skillfully presented by Dr. Jacobson." The book lives up to its title and will be found a valuable monograph for reference on the subject treated. The illustrations are splendid and the bibliography seems to be complete. Dermatologists and pathologists should find this book of considerable interest.

Individuality of the Blood in Biology and in Clinical and Forensic Medicine. By Prof. Leone Lattes, Translated by L. W. Howard Bertie, M.A., B.M., B.CH. (Oxon.) From the French Edition of 1929, Thoroughly Revised and Brought Up to Date by the Author. Oxford Univ. Press, 1932.

This book, originally published in Italy in 1923, has since been translated into German and French and, in its English translation, will undoubtedly be of value to a number of readers. The bibliography of almost 100 pages is in itself evidence of the thoroughness of the author's work. While not all will agree with the author's theories, all hematologists will want to have the book at hand for study and reference.

Livre d'or à l'occasion du jubilé de vingt-cinq ans d'activité chirurgicale du Docteur Theodore L. Papayoannou, Ancien Professeur d'Anatomie à l'Ecole des Beaux-Arts d'Athènes, Directeur et Chirurgien en Chef de l'Hôpital Papayoannou. Naumburg-Saale, Lippert & Co., 1932.

This is an interesting anniversary volume published in honor of the Greek surgeon's golden anniversary in surgery. Articles are in Greek, German and French.

Kosmetische Operationen, Ein kurzer Leitfaden für den Praktiker. By Dr. Ernst Eitner. Wien, Julius Springer, 1932.

This little monograph in 130 pages covers in sketchy and concise fashion the entire subject of cosmetic operations and will serve as a résumé of the possibilities of cosmetic surgery. It is well illustrated and the bibliography makes it a simple matter to look up further references.

Handbuch der gesamten Unfallheilkunde. By Drs. Fritz Konig and Georg Magnus. Stuttgart, Ferdinand Enke, 1932.

The latest part of this work begins Volume II dealing with Industrial Diseases. In this volume, the relation of Industry to Diseases like Lead Poisoning, etc. is taken up in thorough detail. We look forward to a completion of this work which we believe to be one of the most valuable reference textbooks for the industrial surgeon.

Mesenteric Lymphadenitis, A Clinical Study. By J. P. Strombeck. Stockholm

Kungl. Boktryckeriet, P. A. Norstedt & Sons, 1932.

Strombeck, working in Soderlund's clinic in Stockholm, offers in this monograph a careful study of a large series of patients showing by radiographic examination calcification of their mesenteric lymph nodes. The work includes an extensive review of the literature of mesenteric lymphadenitis; also a report of a limited number of cases of acute lymphadenopathies. The material has been carefully analyzed. Unfortunately the results of this analysis, in terms of differential diagnosis, are sufficiently equivocal to leave the reader with but hazy ideas as to how this study may be applied with specific cases. The limited amount of pathological study of the non-calcified nodes leaves many of the conclusions open to question. While the work, for example, represents a clinical study of mesenteric lymphadenitis no mention is made of Hodgkin's disease which, in reality, affects the mesenteric nodes more than any other group within the body. Tabes mesenterica, likewise, receives no emphasis. The monograph must be viewed, therefor, as almost exclusively a study of *calcified* nodes rather than as a broad exposition on intra-abdominal lymphadenopathies in general. The section reviewing the extensive literature proves the portion of perhaps greatest merit. The illustrations are clear and the book is well edited. It should prove of great interest not only to the student of tuberculosis but to the clinician intent upon solving the problem case with abdominal signs and symptoms.

Endocrine Medicine. By William Engelbach, M.D., F.A.C.P., B.S., M.S., D.SC. With a Foreword by Lewellys F. Barker, Springfield, Ill., Charles C. Thomas, 1932. 3 Vols. and an Index Vol. Vol. I. General Considerations; Vol. II. The Infantile Endocrinopathies, The Juvenile Endocrinopathies; Vol. III. The Adolescent Endocrinopathies, The Adult Endocrinopathies.

As Dr. Barker well states in his foreword: "It is a matter of congratulation, that Dr. William Engelbach should have been willing, in the light of his large personal clinical experience, and after a painstaking study of the older and newer literature, to provide us with a summary of endocrinological theory and practice as known in 1931."

This work is published in three volumes of over 1800 pages to be followed by an index volume, and containing 933 illustrations. As a book of reference for the close student who wishes his data complete and up-to-date, there is nothing better in the English language today. The subject is completely covered and well handled though perhaps the average practitioner will find himself lost in the mass of detail. The subject, after all, is new and ideas are changing. No work, therefore, however well done or authoritative, is to be considered as the final word, for changes take place in this subject from day to day. This set will undoubtedly take its place as a definite landmark in the history of endocrine literature and will probably stand as the authoritative presentation of the subject to the end of 1931.

It is because of the subject treated rather than any fault of the book itself that it will before very long need to be revised. We look for much more research and many more publications before a standardization of this subject can possibly be achieved. In the meantime, the author and the publisher are to be congratulated on the most complete presentation of the subject to date.

Diseases of the Spinal Cord. By Williams B. Cadwalader, M.D. Introduction by William G. Spiller, M.D. Balt., Williams & Wilkins Co., 1932.

This book of 200 pages discusses the diseases of the spinal cord in a rather elementary manner. It would seem to be more suitable as a section of a book on nervous diseases than as a separate monograph. The work is based on the lectures given by the author to his students at the University of Pennsylvania. Desirable as it might be to do so, it is doubtful whether many teachers will feel justified in recommending to their students a special monograph on diseases of the spinal cord. The book is well written, well printed, and well illustrated.

The Principles of Orthopedic Surgery for Nurses. By James Warren Sever, M.D. Ed. 2, N. Y., Macmillan Co., 1932.

The second edition of Sever's book brings the subject thoroughly up-to-date in a concise and practical manner. All the information needed by nurses is very apt to be found in this volume and Dr. Sever has avoided the temptation, so common in many of the books on nursing, of overdoing the subject. He has told the nurse all she needs to know, no more, no less, and is to be congratulated on his accomplishment.

PERIPHERAL NERVE INJURIES

LEWIS J. POLLOCK, M.D., AND LOYAL DAVIS, M.D.

ELEVENTH INSTALLMENT

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Chapter XXXII

THE TIBIAL NERVE

In lesions above the popliteal space a complete isolated injury to the tibial nerve is rare. More frequently, as was noted under lesions of the sciatic nerve, partial or dissociated paralysis of the nerve accompanied by more or less complete paralysis of the peroneal nerve occurs. In lesions below the popliteal space the tibial may be completely severed.

Motor Symptoms

The most common motor disturbance which results from a lesion of the tibial nerve is a paralysis of plantar flexion of the foot. Frank adduction of the foot is also impossible. It is always accompanied by elevation of the foot and is then due to contraction of the tibialis anticus. Flexion and separation of the toes are abolished and no muscle or tendon can move in the sole.

The foot may be plantar flexed by the action of the peroneus longus, but feebly. Walking is fatiguing, difficult and often painful. The foot hangs down, is swollen, edematous and discolored. The proximal phalanges are extended, the distal ones flexed. Hyperkeratosis of the sole and ulceration are common. Often the foot is deformed by fibrosis of the tibiotarsal articulation, and the attitude of foot-drop cannot be corrected passively. At times dorsal flexion of the proximal phalanges may produce passive flexion of the distal phalanges and claw-foot result (Fig. 282).

Sensory Symptoms

Subjective sensory disturbances, frequently of a causalgic character, are very common in injuries of the tibial nerve, particularly in incomplete lesions (Fig. 283).

Objective sensibility is lost over the sole, except at the inner border, the lateral surface of the heel, the plantar sur-

face of the toes and at times encroaches on the distal phalanges. The area of the loss of sensation may be seen in the preceding figure. The area of overlap of adjacent nerves includes the

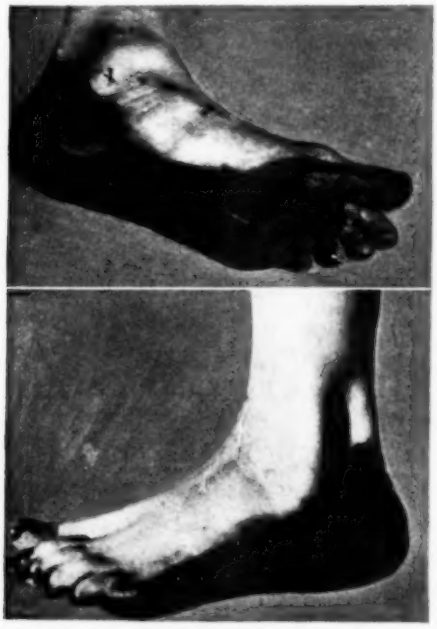

FIG. 282. Paralysis of tibial nerve.

inner border of the sole, much of the lateral surface of the heel and in some cases we have found that it included the plantar surface of the areas between the toes (Fib. 284).

The area of total supply for pain of the tibial nerve was obtained from the residual sensibility in a case of a combined lesion of the small sciatic, the long saphenous, and the peroneal nerves from a case of peroneal section. This is shown in Figure 285.

VASOMOTOR AND TROPHIC SYMPTOMS

The vasomotor and trophic changes are much the same as those seen in sciatic nerve lesions. The symptoms include discoloration of the skin, which may be livid, purplish and glossy; coldness, trophic ulcers of the malleoli, the heel and toes; nail changes; hypotrichosis and hypertrichosis; and edema.

Lesions of the Posterior Tibial Nerve

Paralysis of the posterior tibial nerve frequently occurs as the result of injury in the calf, and produces a paralysis of all

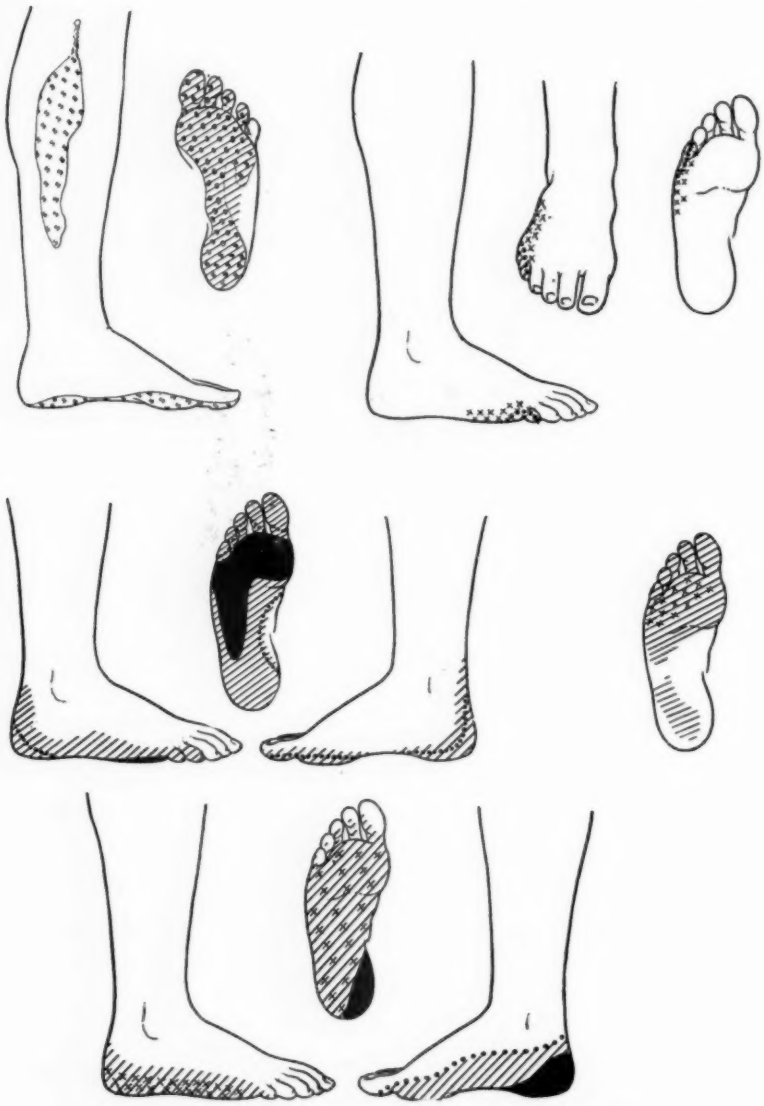

Fig. 283. Sensory loss in partial lesions of tibial nerve.

the muscles of the sole. The nerve lesion very frequently is accompanied by pain of a causalgic nature. At times a dis-

FIG. 284. Overlap of peroneal into tibial nerve area for pain sensation.

FIG. 285. Residual sensibility in tibial nerve lesions.

sociated paralysis of the plantar muscles may be found. Contractures are common, much as they are in ulnar nerve lesions, with dorsal flexion of the proximal and plantar flexion of the

FIG. 286. Paralysis of posterior tibial nerve.

distal phalanges (Fig. 286). In addition to dissociated paralyses, many of these cases showed only partial injury to parts of the posterior tibial or tibial nerves. The sensory disturbances may be visualized by reference to the preceding figure.

ANATOMY

The tibial is the larger of the two terminal divisions of the sciatic trunk and as has been stated arises from the anterior branches of the last two lumbar and first three sacral nerves. It occupies the internal portion of the sciatic trunk in its course through the thigh. After it separates from the peroneal, the tibial descends through the middle of the popliteal space to the lower part of the popliteus muscle. Here it passes beneath the arch of the soleus muscle accompanied by the popliteal artery and terminates as the *posterior tibial* nerve. It is overlapped by the hamstring muscles above and then becomes quite superficial. Opposite the knee joint it is in close relation to the popliteal vessels lying upon the popliteal vein with the artery below the vein. Below this it is again overlapped by the gastrocnemius muscle as it passes between its two heads (Fig. 287A).

The branches of the tibial nerve are *articular, muscular* and one *cutaneous* branch. The articular branches are three in number and supply the knee joint. They are difficult to dissect

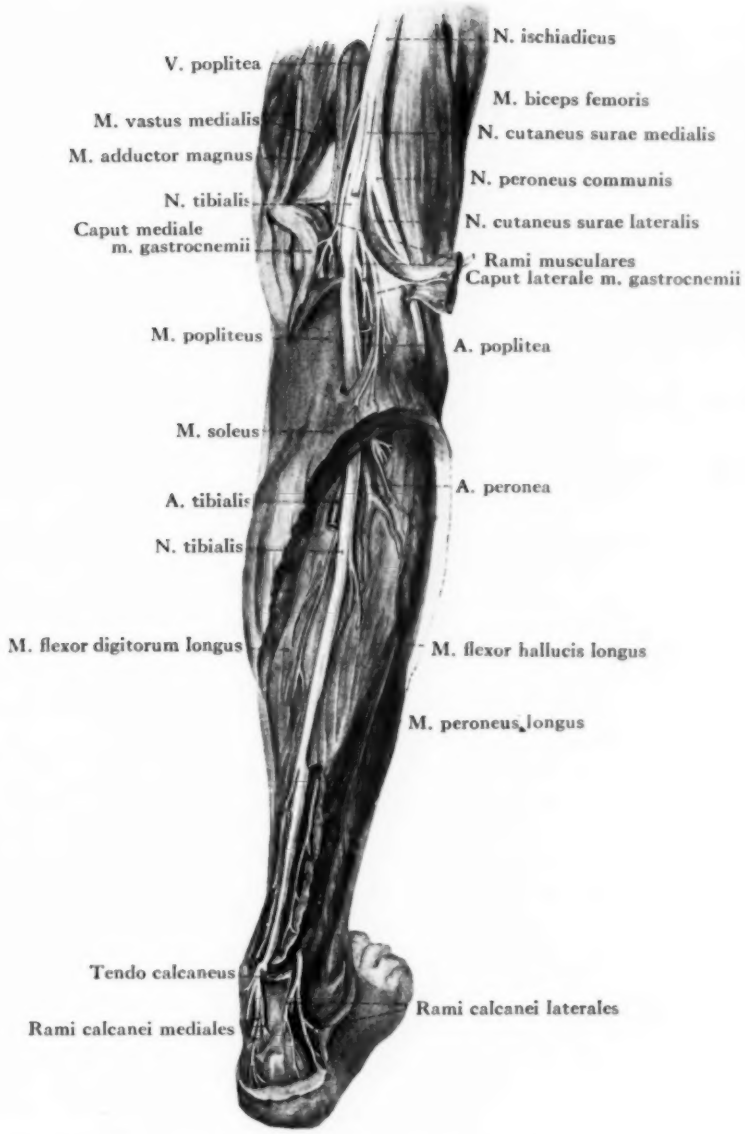

FIG. 287A. Anatomical course of tibial nerve.

but two of them accompany the superior and inferior internal articular arteries while the third follows the azygos articular artery. Four or five muscular branches are given off in the

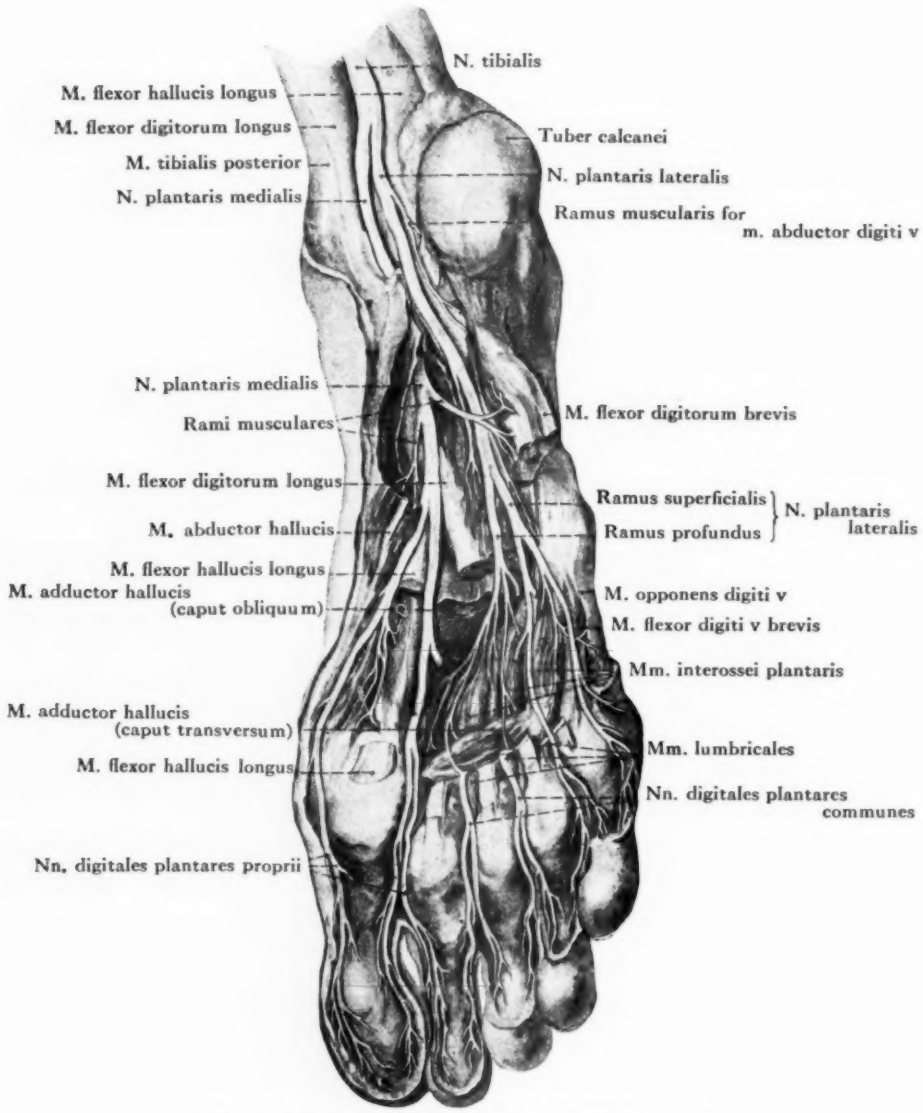

FIG. 287B. Terminal branches of tibial nerve.

popliteal space. Two of these arise from the tibial nerve near the apex of the popliteal space. They diverge from the nerve

trunk and enter the medial and lateral heads of the gastrocnemius muscle. A branch to the soleus muscle may arise from the tibial trunk or from the branch to the gastrocnemius. It

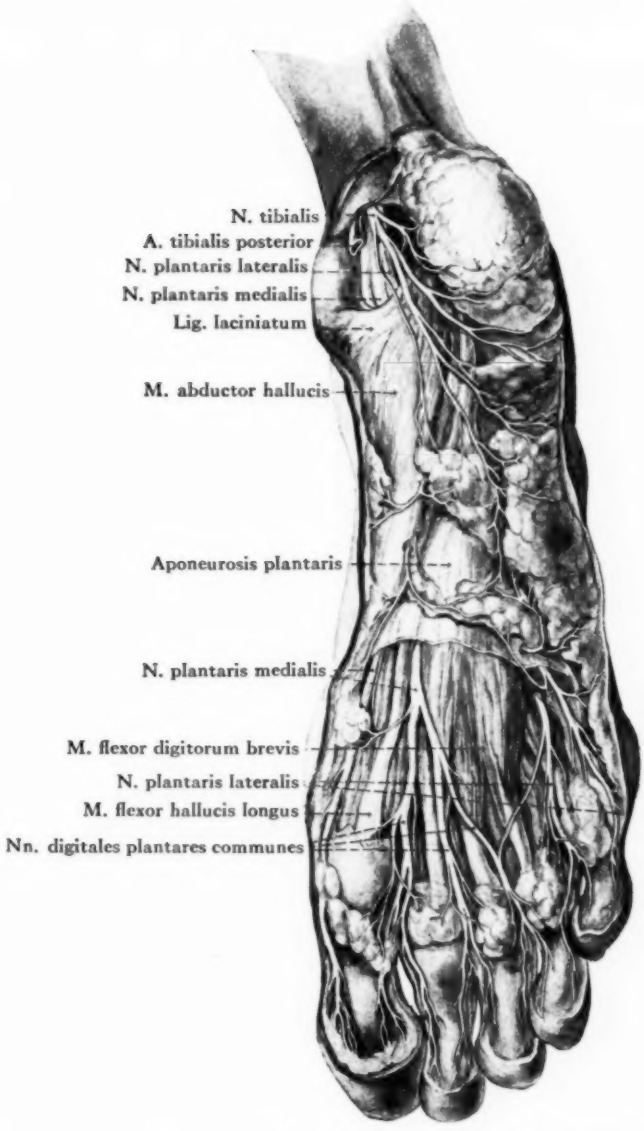

FIG. 287C. Superficial plantar nerves.

enters the superficial surface of the soleus just in front of the lateral head of the gastrocnemius. The plantaris and the

popliteus muscles are also supplied by branches of the tibial given off at this level. The *medial sural cutaneous nerve* (communicans tibialis) descends between the two heads of the gastrocnemius and pierces the deep fascia about the middle of the posterior surface of the leg. It joins a branch from the peroneal to form the external saphenous nerve to the interval between the os calcis and external malleolus. Here it divides into an anterior branch which supplies the skin along the outer side of the foot and little toes; and a posterior branch which forms the lateral calcaneal cutaneous nerve.

The *posterior tibial* nerve, which is the continuation of the tibial trunk, descends along the back part of the leg with the posterior tibial vessels to the interval between the internal malleolus and the os calcis. Here it divides into its terminals, the *internal* and *external plantar* nerves. The nerve is covered by the muscles of the calf and at a lower level only by the skin and fascia. Above it lies to the inner side of the tibial artery but it crosses this vessel and then lies externally as far as the ankle. In the lower third of the leg it is parallel to the Achilles tendon.

The collateral branches of the posterior tibial nerve are the *articular* which supplies the ankle joint; the *internal calcaneal* which supplies the skin of the heel and inner side of the foot and the *muscular* branches. The latter supply the deep surface of the soleus, posterior tibial, flexor longus digitorum and the flexor longus hallucis muscles. Thus the soleus receives a double nerve supply, one deep and one superficial.

The *internal plantar*, the larger of the two terminal branches of the posterior tibial, passes forward beneath the abductor hallucis muscle and between it and the flexor brevis digitorum to divide opposite the metatarsal-tarsal articulations into four *plantar digital* nerves. During its course, it gives off cutaneous branches which supply the skin of the sole of the foot and muscular branches which supply the abductor hallucis and flexor brevis digitorum muscles. Articular branches supply the tarsal-metatarsal articulations. The four terminal

digital branches are distributed similar to the digital branches of the median nerve in the hand. The first supplies the skin over the inner border of the large toe and innervates the flexor brevis hallucis muscle. The second supplies the skin of the adjacent sides of the large and second toes and innervates the first lumbrical muscle. The third supplies the cutaneous innervation for the adjacent sides of the second and third toes, and the fourth supplies the skin over the corresponding sides of the third and fourth toes. (Fig. 287B and C.)

The *external plantar*, which is the smaller terminal of the posterior tibial, passes forward with the external plantar artery to the outer side of the foot. It lies between the flexor brevis digitorum and flexor accessorius.

In the interval between the former and the abductor minimi digiti, it divides into a superficial and deep branch. Before this division occurs it supplies the flexor accessorius and the abductor muscles. The superficial branch separates into two digital nerves, one of which supplies the outer side of the little toe, the flexor brevis minimi digiti and the two interosseous muscles of the fourth metatarsal space. The other supplies the adjacent sides of the fourth and fifth toes. The deep branch accompanies the external plantar artery beneath the tendons of the flexor muscles and the adductor obliquus hallucis muscles. It supplies all the interossei, with the exception of those in the fourth metatarsal space, the three lateral lumbricales, the adductor obliquus hallucis and the adductor transversus hallucis muscles. It will be recognized that the distribution of the external plantar is similar to that of the ulnar.

Physiology

The *popliteus* muscle flexes the leg upon the thigh.

The *plantaris* is inconstant and has no specific action.

The *gastrocnemius* and *soleus* have a united action. They plantar-flex the foot in adduction.

The *tibialis posticus* muscle is a pure adductor of the foot.

The *flexor longus digitorum* flexes the terminal phalanges of the four smaller toes.

The *flexor hallucis longus* flexes the second phalanx of the great toe.

There are three muscles in the foot which correspond to the muscles of the thenar eminence in the hand. The *adductor obliquus hallucis* separates the large and second toes. The *flexor brevis hallucis* flexes the first phalanx of the large toe on the metatarsal bone. The *abductor hallucis* flexes the large toe and brings it nearer the second toe.

There are three muscles which correspond to the hypothenar eminence. These are the *abductor minimi digiti*, the *flexor brevis minimi digiti* and the *opponens minimi digiti*. All of them flex the small toe upon the fifth metatarsal bone.

In addition the *flexor brevis digitorum* muscle flexes the second phalanx of the four smaller toes.

There are *lumbrical* muscles similar to those in the hand and three plantar and four dorsal interossei muscles. They flex the first and extend the last phalanges of each toe. The interossei also abduct and adduct the toes.

Surgery

The incision used for exposure of the popliteal space may be continued down the leg to expose the tibial nerve in the upper part of its course. It lies between the intermuscular septum between the deep and superficial muscles of the calf (Fig. 288). It passes through the tendinous arch of the soleus muscle with the tibial muscles. The gastrocnemius should be retracted and the union between its two heads separated. If it is desired to expose the nerve in the middle or lower portion of the leg, an incision should be made along the medial border of the calf about 3 to 4 cm. from the margin of the tibia. The deep fascia, with its transverse fibers, is cut and the intermuscular septum identified. The nerve in this

position lies lateral to the artery. The lower in the leg the tibial nerve is sought the easier becomes its exposure.

A curved incision about 10 cm. long parallel to the dorsal

FIG. 288. Line of incision to expose tibial nerve.

border of the medial malleolus should be made to expose the internal and external nerves. The internal arcuate ligament should be exposed and divided. Immediately behind the malleolus are the sheaths for the tibialis posterior and flexor digitorum longus tendons. Below the latter are the plantar nerves and vessels. They enter the sole of the foot lying on the deep surface of the abductor hallucis muscle.

Chapter XXXIII

THE LUMBOSACRAL PLEXUS

Intrapelvic injury to the lumbosacral plexus may result from fractures and dislocations of and about the pelvis, from gunshot and stab wounds and from compression. Such isolated paralyses have only rarely been observed. In such a case Hartman reported a paralysis of the sciatic, obturator, femoral and gluteal nerves. Isolated paralysis of the ilio-hypogastric nerve with paralysis of a segment of the abdominal wall and with loss of sensation over the lateral lower abdomen has been observed. Paralysis of the obturator with paralysis of all of the abductors of the thigh and no sensory loss has likewise been observed. A lesion of the genitofemoral nerve has been noted by Leri and Bouvent. In this case sharp pain in the inguinal region at the right side of the scrotum radiated to the thigh. There was retention of urine, followed by painful micturition and anesthesia on the upper part of the thigh and external iliac fossa.

The *pudic nerve*, when found injured on rare occasions, gave rise to painful sensations. There was difficulty and burning on micturition and defecation; partial incontinence of urine and feces; pain in the anus, perineum and one side of the penis; and a semi-erection on micturition.

Lesions of the *lateral cutaneous nerve*, so often involved in civil life in neuralgia and paresthesia, gave rise to neuralgic pains similar to those seen in causalgia. Others showed nothing but sensory loss and required no treatment.

The *small sciatic nerve* was injured frequently in conjunction with lesions of the sciatic and produced loss of sensibility over the posterior surface of the thigh (Fig. 289). At times hyperesthesia was noted.

The important branches of this plexus which require description are the gluteal nerves, the femoral, the sciatic and its branches.

GLUTEAL NERVES: The *gluteal nerves* are rarely injured alone. The inferior gluteal, which supplies the gluteus maximus, was injured more frequently than the superior. The gluteus

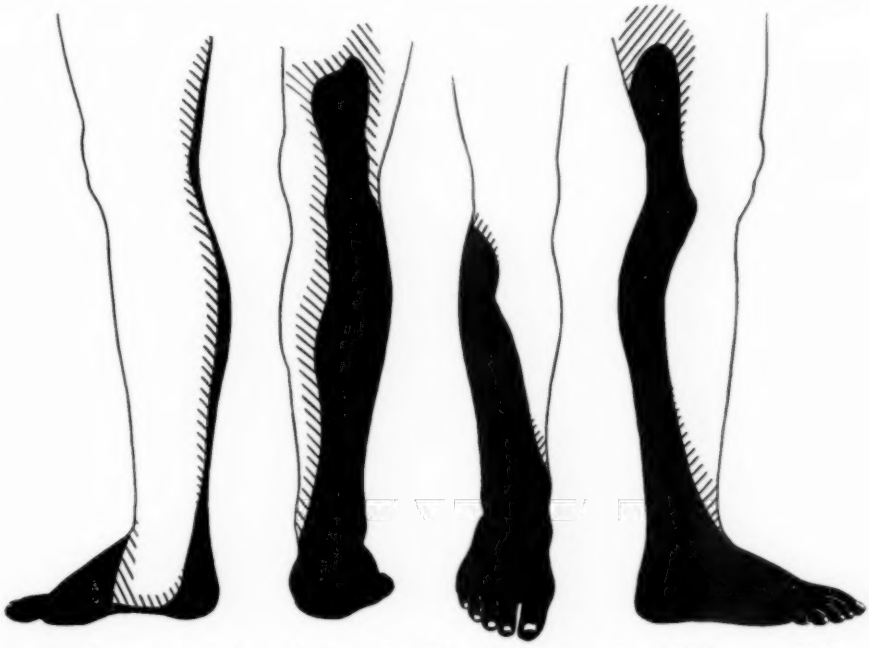

FIG. 289. Sensory loss in a lesion of small sciatic nerve in addition to a lesion of sciatic nerve.

maximus is a very powerful extensor of the thigh on the pelvis. When it is paralyzed, there is difficulty in raising oneself from a seated position, and difficulty is experienced in going upstairs, jumping and running. When unilaterally injured, the paralysis may be determined by having the patient lie upon the abdomen and by contraction bring the buttocks together (Fig. 290).

The superior gluteal nerve supplies the gluteus medius and minimus. Their action produces adduction of the thighs. It plays an important part in the fixation of the pelvis when the hip is flexed, as in the second phase of walking. When paralyzed, there is an inclination of the pelvis to the opposite side when the patient stands on the affected limb.

In testing these muscles the patient is instructed to resist passive adduction of the abducted thigh.

The rarity of observations upon isolated injuries to the intrapelvic branches of the lumbosacral plexus is due largely to the serious character of the wounds which produce them.

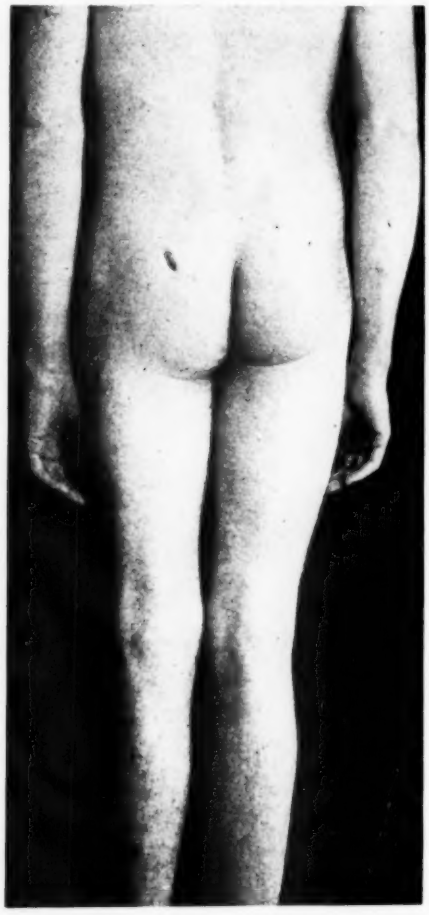

FIG. 290. Paresis of left gluteal muscle due to stab wound nerve lesion.

The lumbosacral plexus may be more easily understood if it is considered in its two components; the lumbar plexus and the sacral plexus. However, it is of simple structure as compared to the brachial plexus.

ANATOMY OF THE LUMBAR PLEXUS

The lumbar plexus consists of a union of the anterior branches of the first three lumbar spinal nerves. Occasionally

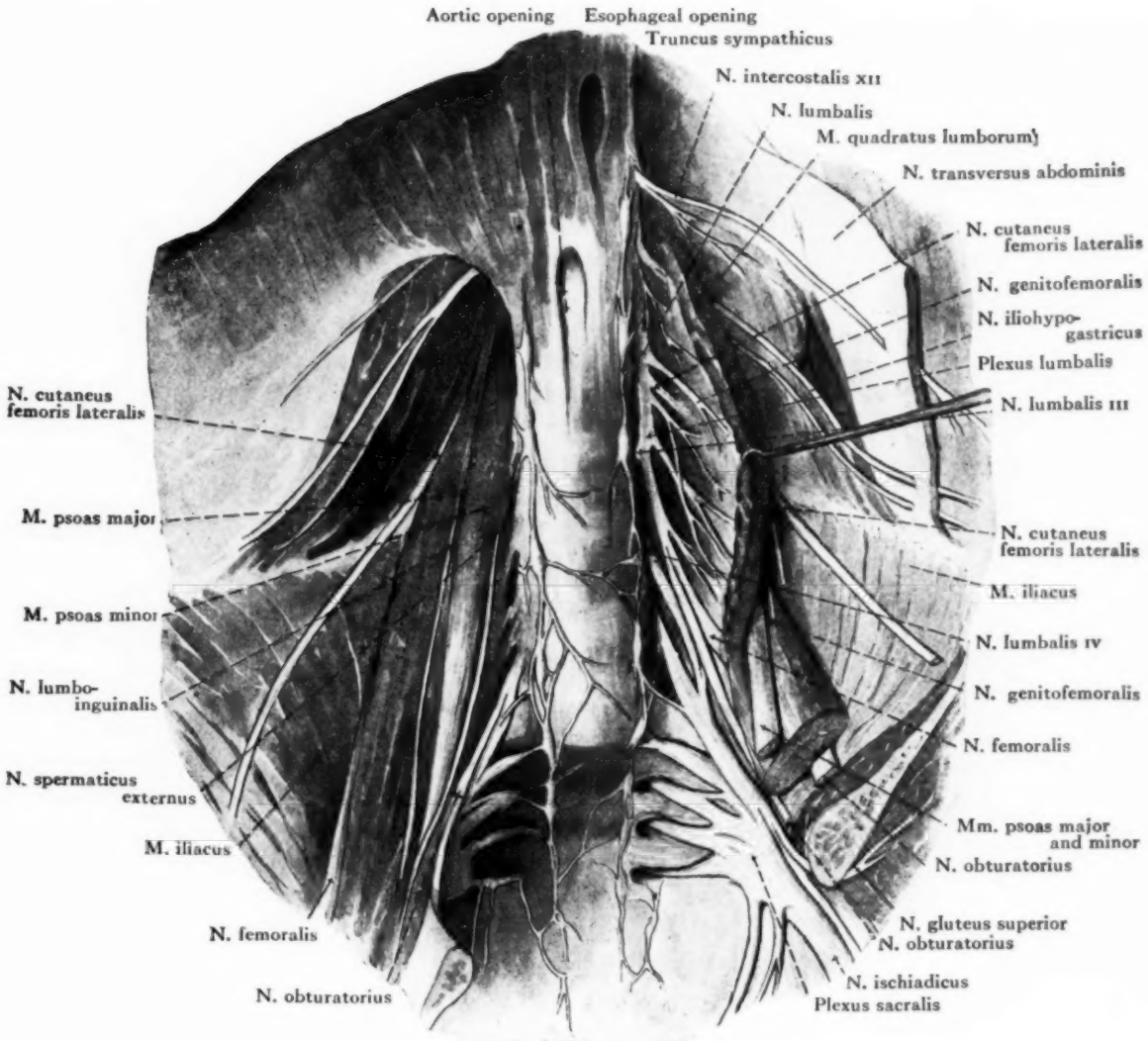

FIG. 291. Diagram of lumbosacral plexus.

it receives a contribution from the fourth lumbar and more often one from the twelfth dorsal. It is situated within the substance of the psoas muscle (Fig. 291).

The anterior branch of the first lumbar nerve receives an anastomosing twig from the twelfth spinal nerve and then divides into three branches. Two of these pass forward parallel to the twelfth intercostal and become the iliohypogastric and the ilioinguinal nerves. The remaining branch descends along the vertebral column and unites with the second lumbar nerve.

The anterior branch of the second lumbar nerve also gives off three branches. One of these passes forward and becomes the genitofemoral nerve; another passes more posteriorly and becomes the lateral cutaneous nerve of the thigh while the third branch which lies between these two descends vertically and after bifurcating sends one twig to the femoral and another to the obturator nerves.

The anterior branch of the third lumbar nerve quickly divides into a larger division which becomes the superior root of the femoral nerve and a smaller division which becomes the superior root of the obturator nerve.

The anterior branch of the fourth lumbar nerve almost immediately divides into three branches. The superior of these unites with the femoral nerve, the middle with the obturator and the inferior descends to join the fifth lumbar spinal nerve. The femoral and obturator nerves, therefore, are the terminal branches of the lumbar plexus.

All of the roots of the lumbar plexus are not situated upon the same plane. The superior and inferior roots are more anteriorly placed than the middle roots due to the normal curvature of the lumbar vertebral column. The plexus is situated in a plane of cleavage between two layers of the psoas muscle. There the nerves are in relation with the lumbar veins and arteries. The veins may pass either anterior or posterior to the nerves and occasionally they may divide to enclose the nerves in a loop. The intercostal branches of the lumbar arteries pass anterior to the nerves of the plexus. (Fig. 292.)

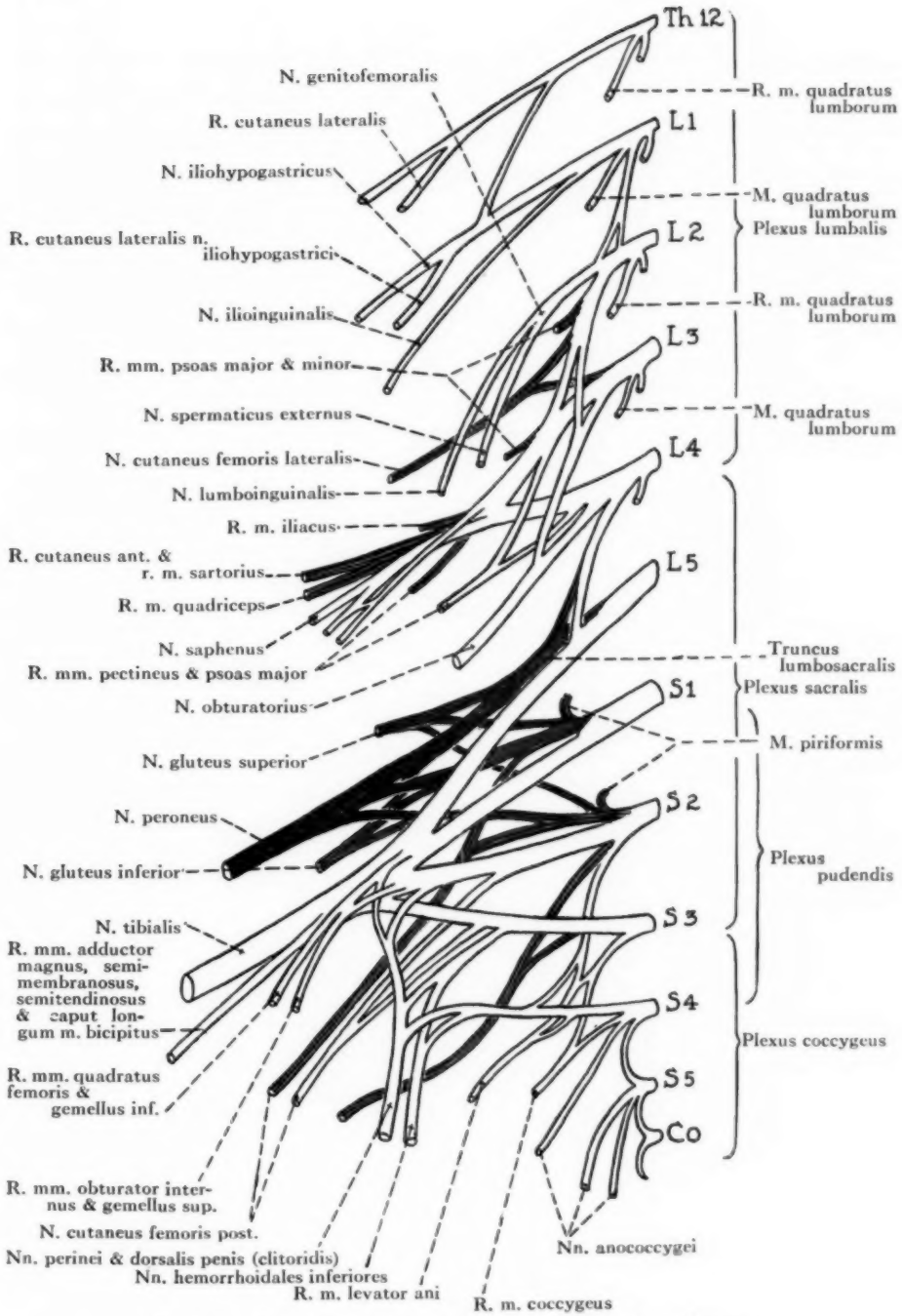

FIG. 292. Drawing to illustrate anatomy of lumbar plexus.

The white and grey rami communicantes between the nerves of the lumbar plexus and the sympathetic system are very irregular in their disposition. There may be only one pair of rami communicantes or there may be three and Hartman has described five rami connected with the first lumbar nerves alone.

A small short twig arises from each of the anterior branches of the first four lumbar spinal nerves near their origin and supplies the four lumbar intertransversarius muscles.

The *nerves to the quadratus lumborum* muscle arise from the first three lumbar nerves immediately lateral to the above named branches. They pass behind the plexus and penetrate the posterior layer of the psoas after which they pierce the anterior surface of the quadratus lumborum.

The *nerves to the psoas* muscle are variable in number although it is more common for there to be three or four. They arise from the superior root of the femoral nerve and from the common trunk formed by the middle roots of both the femoral and obturator nerves. The nerves course inferiorly and externally in front of the plexus and ramify extensively before penetrating the posterior surface of the anterior layer of the psoas muscle.

The *iliohypogastric* nerve arises from the anterior branch of the first lumbar nerve. It passes freely and externally within the substance of the psoas muscle parallel to and between the twelfth and intercostal and ilioinguinal nerves. It appears at the external border of the psoas and lies upon the quadratus lumborum. The nerve then passes still more obliquely inferiorly and laterally and at the external border of the quadratus it perforates the transversalis fascia just above the crest of the ilium. It gives off muscular branches to the abdominal wall and divides into its terminal iliac and hypogastric branches. The former perforates the internal and external oblique muscles and supplies the skin of the gluteal region. The latter runs forward between the internal oblique and transversalis muscles. It pierces the internal oblique and becomes cutaneous

by perforating the external oblique just above and lateral to the external abdominal ring. It supplies the skin over the hypogastric region.

The *ilioinguinal* nerve arises from the anterior branch of the first lumbar nerve. It appears at the lateral border of the psoas just below the iliohypogastric. It passes obliquely across the quadratus lumborum and pierces the transversalis muscle near the crest of the ilium. It communicates with the iliohypogastric between the transversalis and internal oblique muscles. It then pierces the internal oblique as it passes forward and medially and gives off branches to that muscle. The nerve accompanies the spermatic cord through the external abdominal ring. It becomes superficial and supplies the skin of the upper and inner part of the thigh, the root of the penis and the scrotum in the male and to the skin covering the mons veneris and labium major in the female.

The *genitofemoral* nerve arises from the anterior branch of the second lumbar nerve but it is not uncommon for it to have an accessory root from the first lumbar. It passes obliquely through the psoas muscle and appears at its medial border at the level of the third lumbar intervertebral space. It descends on the anterior surface of this muscle, lying behind the peritoneum, and at a variable level divides into two terminations. The genital or external spermatic branch pierces the transversalis fascia, or passes through the internal abdominal ring. In the male it follows along the posterior surface of the spermatic cord into the scrotum and supplies the cremaster muscle. In the female it accompanies and supplies the round ligament. The femoral branch descends with the external iliac artery beneath Poupart's ligament and over the sartorius muscle. It divides into an anterior and posterior branch which supply the skin of the anterolateral and posterolateral surfaces of the thigh. The terminal branches of the lumbar plexus are the femoral and obturator nerves. They will be considered separately in more detail.

Physiology of the Lumbar Plexus

The *quadratus lumborum* muscle draws down the last rib. If the thorax and vertebral column are fixed the muscles acting together may flex the trunk.

The iliopsoas muscle flexes the thigh on the pelvis and with the femur fixed both of these muscles bend the lumbar portion of the vertebral column and pelvis forward.

Surgery of the Lumbar Plexus

Because of their comparatively long course within the spinal canal the nerves of the lumbar plexus are involved more commonly in lesions affecting the lower thoracic and upper lumbar spinal column. In civil life these lesions include tumors of the cauda equina, fracture dislocations of the vertebrae, and bullet injuries of the spinal canal. The surgical approach to the cauda equina is, of course, by a laminectomy of the lumbar vertebrae. If divided within the canal, the nerves may be sutured since their structure is that of a peripheral nerve though they lie within the dural sac. The nerves are less commonly injured in their course outside the spinal canal and when they are so involved there is usually a large destructive lesion of the soft tissue which overshadows the nerve lesion. Attempts to isolate and suture the nerves in their peripheral course are impractical.

Anatomy of the Sacral Plexus

The sacral plexus is formed by the lumbosacral cord and the anterior branches of the first sacral and portions of the second and third sacral spinal nerves. The lumbosacral cord consists of the union of a part of the anterior branch of the fourth lumbar and the entire anterior branch of the fifth lumbar nerves (Fig. 293).

The plexus lies against the posterior wall of the pelvic cavity and rests upon the anterior surface of the pyriformis muscle. It has the shape of a right-angled triangle, two sides

of which are formed by the anterior branch of the third sacral nerve and the vertebral column. The hypothenuse of the triangle is formed by the lumbosacral cord and the apex is at

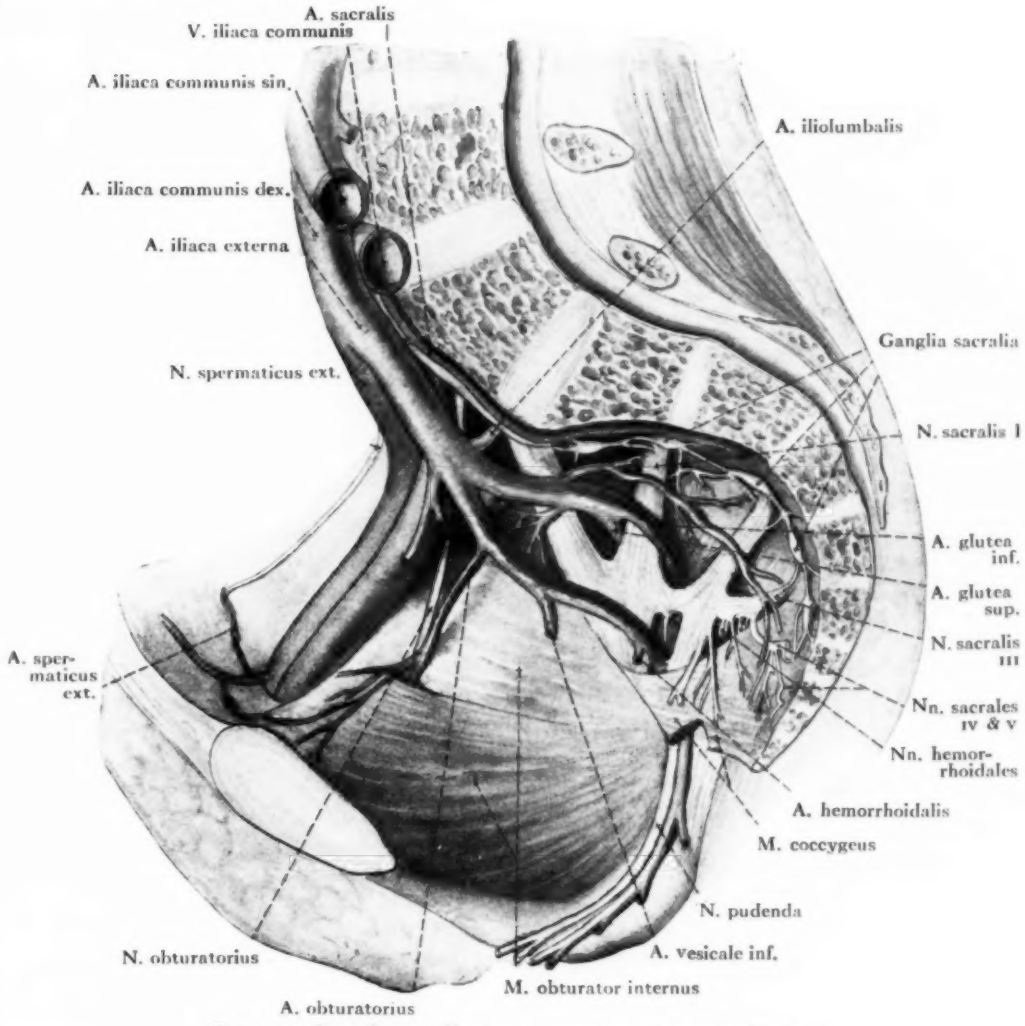

FIG. 293. Drawing to illustrate anatomy of sacral plexus.

the lower part of the greater sacrosciatic foramen. It is covered anteriorly by the pelvic fascia which separates it from the internal iliac vessels, the ureter and the pelvic colon. The gluteal blood vessels run between the lumbosacral cord and

the first sacral nerve, and the sciatic vessels between the second and third sacral nerves.

Each of the spinal nerves which contribute to the formation of the plexus receives a grey ramus communicans from the sympathetic ganglia. A white ramus from the third sacral and occasionally from the second and fourth sacral nerves is given to the sympathetic pelvic plexus.

The nerve to the quadratus femoris and gemellus inferior; the nerve to the obturator internus; the nerve to the pyriformis; the superior and inferior gluteal nerves and the small sciatic nerve are the collateral branches of the sacral plexus. The sciatic nerve is the terminal branch of the plexus and will be discussed separately in detail.

The *nerve to the quadratus femoris and gemellus inferior* arises from the anterior divisions of the fourth and fifth lumbar and the first sacral spinal nerves. It leaves the pelvis through the greater sacrosciatic foramen and descends beneath the sciatic nerve, gemelli muscles and the tendon of the obturator internus.

The *nerve to the obturator internus* arises from the anterior divisions of the fifth lumbar and first and second sacral spinal nerves. It leaves the pelvis through the greater sacrosciatic foramen below the pyriformis. It re-enters the pelvis through the lesser sacrosciatic foramen and ends within the obturator internus muscle. It gives off a branch to the gemellus superior muscle.

The *nerve to the pyriformis* arises from the posterior divisions of the first and second sacral spinal nerves. It innervates this muscle by entering its anterior surface.

The *superior gluteal* nerve arises from the posterior divisions of the fourth and fifth lumbar and first sacral spinal nerves. It leaves the pelvis through the greater sacrosciatic foramen above the pyriformis muscle in company with the gluteal vessels. The nerve divides into a superior and an inferior branch. The former accompanies the deep gluteal artery and ends in the gluteus minimus muscle. It also gives off a branch

to the gluteus medius. The inferior branch accompanies the lower branch of the gluteal artery across the gluteus minimus and supplies that muscle and the gluteus medius. It ends in the tensor fasciae femoris.

The *inferior gluteal* nerve arises from the posterior divisions of the fifth lumbar and first and second sacral spinal nerves. It leaves the pelvis through the greater sacrosciatic foramen below the pyriformis muscle. The nerve has a curved course with a superior concavity and divides into many branches which penetrate the gluteus maximus muscle.

The *small sciatic* nerve arises in part from both the anterior and posterior divisions of the first, second and third sacral spinal nerves. It leaves the pelvis through the greater sacrosciatic foramen below the pyriformis muscle. It descends beneath the gluteus maximus muscle with the sciatic artery and passes down the posterior surface of the thigh beneath the fascia lata. It continues to the lower part of the popliteal space, passing over the long head of the biceps femoris muscle. It pierces the fascia at that point and accompanies the external saphenous vein. The branches of this nerve are all cutaneous. The gluteal branches turn upward around the lower border of the gluteus maximus to supply the skin covering the lower and outer part of that muscle. The perineal branches are distributed to the skin of the upper and inner side of the thigh on its posterior surface. One of the branches, longer than the others, the *inferior pudendal*, curves forward beneath the superficial fascia of the perineum and is distributed to the skin of the scrotum in the male and the labium major in the female. The femoral branches descend and are distributed to the back and inner sides of the thigh to the skin over the popliteal space and to that over the upper part of the leg.

Physiology of the Sacral Plexus

The *gluteus maximus* muscle is a powerful extensor of the thigh upon the pelvis and of the pelvis upon the thigh. It also produces outward rotation of the thigh.

Contraction of the *gluteus medius* muscle in its entirety produces direct abduction of the thigh. Isolated contraction of the anterior fibers produces internal rotation with abduction and slight flexion while contraction of the posterior fibers causes external rotation with abduction and extension. It also aids in fixation of the pelvis.

The *gluteus minimus* has the same action as the gluteus medius.

The *tensor fasciae femoris* flexes and internally rotates the thigh. It also tenses the external part of the femoral fascia.

The *pyramidalis, gemelli, quadratus femoris and obturator internus* muscles are all external rotators of the thigh.

Surgery of the Sacral Plexus

The surgical lesions of the sacral plexus and its collateral branches are similar in extent and nature to those described under the lumbar plexus.

Chapter XXXIV

THE FEMORAL NERVE

Injuries to the femoral nerve were observed in the War in less than 1 to 2 per cent of the cases studied. They occurred as the result of stab and gunshot wounds, fractures about the

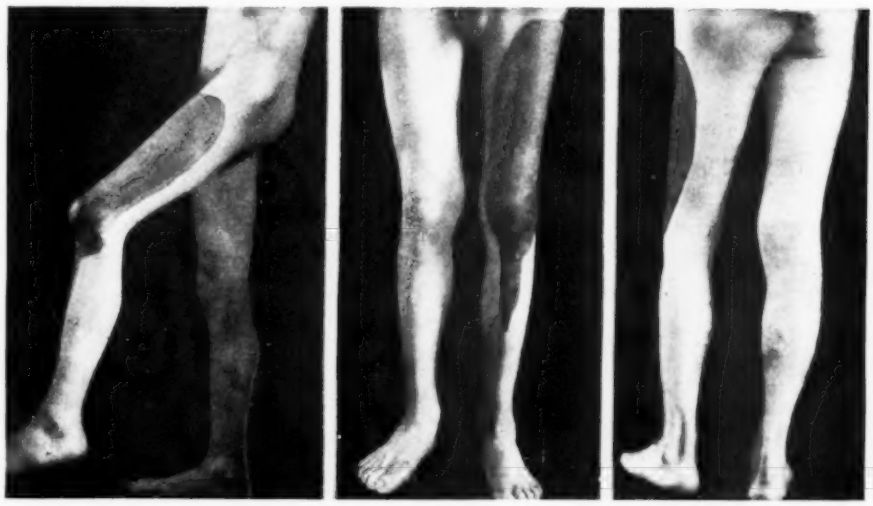

Fig. 294. Injury to femoral nerve with sensory loss over musculocutaneous.

pelvis, and aneurysms of the femoral artery. In civil life, tumors, tuberculosis, psoas abscess, reduction of congenitally dislocated hips, operative wounds, mononeuritis and prolonged gynecologic operations with the thighs strongly abducted, have caused its paralysis. When injured at the highest part of the thigh, below Poupart's ligament, all the terminal branches of the nerve are affected, and in addition to the quadriceps, other muscular branches are affected. Inasmuch as the terminal branches are immediately dispersed, commonly it is the nerve to the quadriceps or the internal saphenous which is injured. In none of our cases were all the branches involved. In the majority only the branch to the quadriceps was injured. When the long saphenous alone was injured no muscular paralysis occurred (Fig. 294).

Motor Symptoms

When the paralysis includes all of the branches, the hip joint can not be flexed and the leg can not be extended. When

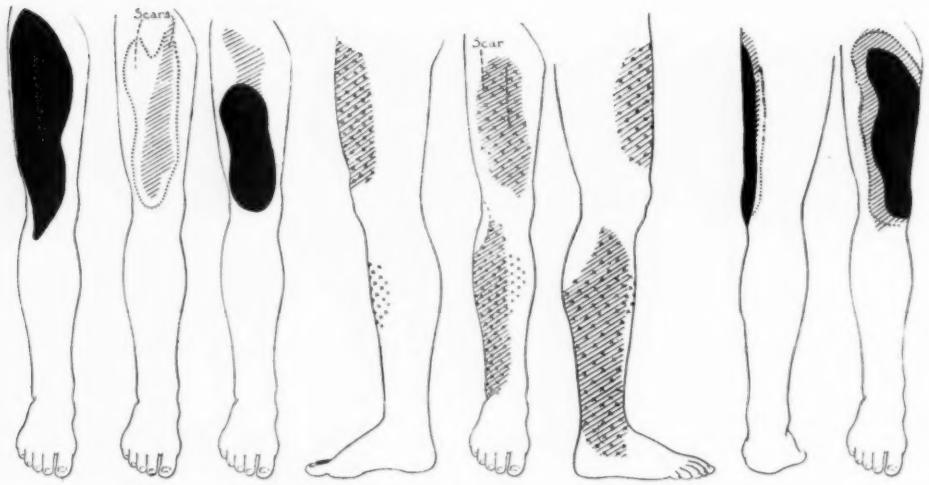

Fig. 295. Sensory loss in femoral nerve lesions.

only the terminal branches to the extensors of the leg are paralyzed, the patient walks in a manner to avoid bending the knee. Walking is extremely difficult and frequently the leg gives way at the knee, causing the patient to fall. Often the patient walks backward, attempting to produce a hyperextension at the knee to prevent the leg from giving way. The lower extremity is often flexed at the hip, then flung forward and slapped down. This gives the appearance of a pseudosteppage gait. At the same time the trunk is bent forward and the uninjured extremity is advanced by a short step. Often assistance in keeping the leg extended is rendered by pressure backward upon the thigh by the hand of the affected side. The knee jerk is diminished or absent.

Atrophy is seen over the thigh and the markings of the thigh brought about by the tensing of the aponeurotic covering when the quadriceps contracts are missing.

Sensory Symptoms

The sensory changes vary. There may be a loss over the outer surface of the thigh and the inner surface of the leg.

Fig. 296. Injury to long saphenous nerve.

However, in the majority of our cases only the motor branch to the quadriceps muscle was injured and the sensory loss corresponded to the area of the middle and internal cutaneous branches (Fig. 295).

Signs of Recovery

The general tendency in our cases was toward spontaneous recovery, and none of the cases came to operation. Disability in walking persisted after return of function in the muscles and probably was due to weakness or distention of the aponeurotic covering of the knee joint, as has been pointed out by Meige.

Long Saphenous Branch

The *long saphenous* nerve is more often involved than the other terminal branches and produces a loss of sensation on

the inner surface of the leg. Subjectively, sharp pain may occur along its distribution. Usually the pain subsides, and in only one case, in which the sciatic nerve was also injured, was there severe pain of a causalgic nature sufficient to warrant operative interference (Fig. 296).

The femoral nerve arises from the anterior divisions of the second, third and fourth lumbar nerves and is the largest branch of the lumbar plexus. Occasionally it may receive an additional contribution from the first or fifth lumbar nerves. It passes downward through the fibers of the psoas muscle, emerges from within the substance of the muscle at the lower part of its lateral edge and continues downward between it and the iliacus muscle. The iliac fascia separates the nerve from the peritoneum and the cecum on the right and the colon on the left. The nerve passes beneath Poupart's ligament where it is separated from the femoral artery by the psoas minor muscle. As it enters the thigh it becomes flattened and divides into an anterior and posterior division (Fig. 297).

Within the abdomen the femoral gives off three to four muscular branches to the iliacus muscle and a small branch to the inferior portion of the psoas muscle. A variable number of branches supply the femoral artery which are distributed to the upper portion of that vessel. Beneath Poupart's ligament the nerve lies above and lateral to the femoral artery.

From the anterior of the terminal divisions of the nerve arise the *middle* and *internal cutaneous* nerves and *muscular branches*. The middle cutaneous nerve pierces the fascia lata about 3 inches below Poupart's ligament and descends along the anterior surface of the thigh to supply the skin and subcutaneous tissue as low as the knee. Here its branches anastomose with those of the internal cutaneous and the long saphenous nerve to form the patellar plexus. The internal cutaneous passes obliquely across the sheath of the femoral artery and divides into an anterior and posterior branch. The former descends on the sartorius muscle and perforates the fascia lata at the lower third of the thigh. Here it divides into

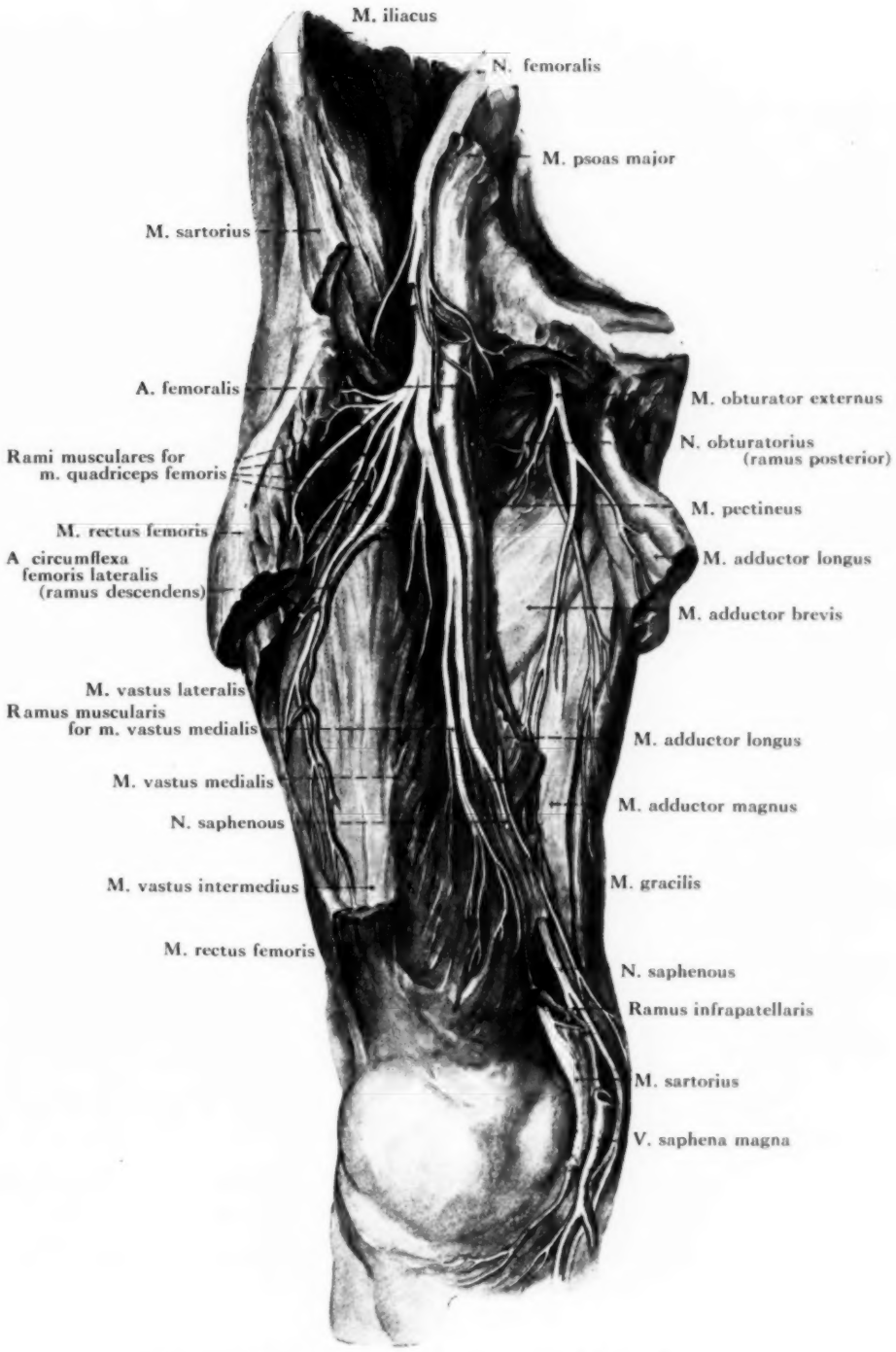

FIG. 297. Drawing to illustrate anatomy of femoral nerve.

a branch which supplies the skin on the inner side of the thigh as low as the knee. The posterior branch descends along the inner border of the sartorius muscle to the knee where it pierces the fascia lata and then continues downward to supply the skin of the inner aspect of the leg. The muscular branches supply the pectineus muscle just below the inguinal ligament. A second branch supplies the sartorius muscle at the level of the origin of the middle cutaneous nerve.

The *long saphenous* nerve is the largest cutaneous branch of the femoral and arises from its posterior terminal division. It lies in front of the femoral artery beneath the aponeurosis of Hunter's canal as far as the opening in the lower part of the adductor magnus muscle. It then passes medially, leaving the course of the artery, and descends along the inner aspect of the thigh beneath the sartorius muscle. It pierces the fascia lata between the sartorius and gracilis tendons and becomes subcutaneous. The nerve then continues distally along the inner side of the leg, accompanied by the internal saphenous vein. It passes behind the internal border of the tibia and at the lower third of the leg divides into two branches. One of these continues along the margin of the tibia to terminate at the ankle while the other passes in front of the ankle and is distributed to the skin along the inner side of the foot as far as the great toe. (Fig. 298.) A rather large patellar branch supplies the skin in front of the patella and helps form the patellar plexus. The muscular branches of the posterior division of the femoral nerve supply the four portions of the quadriceps extensor muscle. The branch to the rectus femoris is given off high in the thigh and enters its under surface. A small filament of this branch supplies the hip joint. The branch to the vastus externus is large and follows the course of the descending branch of the external circumflex artery to the lower portion of the muscle. It also supplies a twig to the knee joint. The branch to the vastus internus is long and descends with the long saphenous nerve along the external side of the femoral vessels. It enters the muscle at its middle and it too supplies a

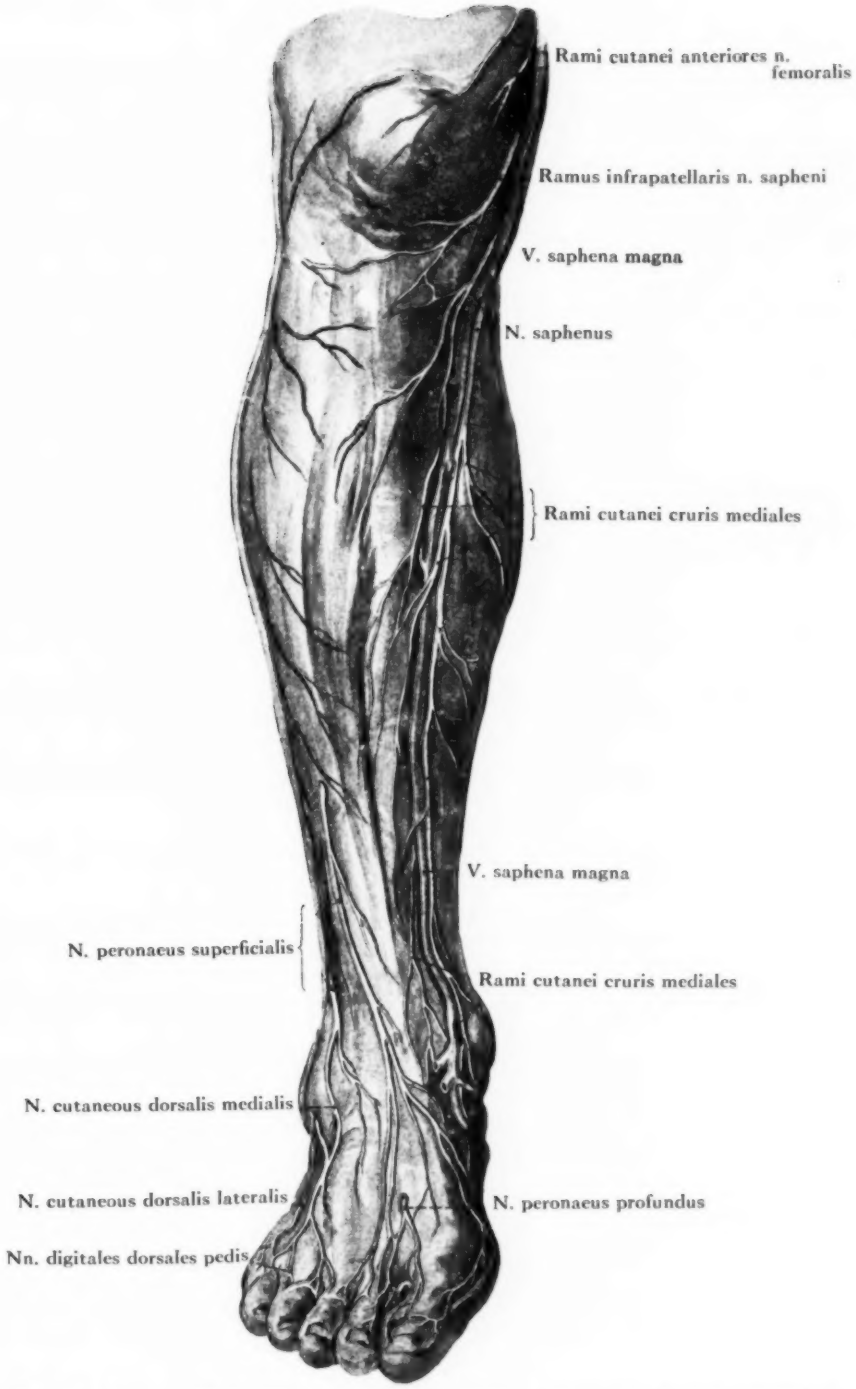

FIG. 298. Drawing to illustrate anatomy of cutaneous nerves of lower extremity.

filament to the knee joint. The nerves to the vastus intermedius are several in number and enter the muscle on its anterior surface at about the middle of the thigh. A twig from this nerve also supplies the knee joint.

Physiology

The femoral nerve supplies the muscles of the anterior femoral region. These are the *sartorius* and the components of the *quadriceps extensor* (rectus femoris, vastus externus, vastus internus, vastus intermedius and the subcrureus). The sartorius muscle primarily flexes the leg upon the thigh but as it continues its action it flexes the thigh upon the pelvis and rotates the thigh outward. When the knee is bent, the sartorius assists the semitendinosus and semimembranosus to rotate the tibia internally.

The quadriceps extensor group extends the leg upon the thigh. In addition the rectus femoris assists the iliopsoas to support the pelvis and trunk on the femur. It also assists in flexing the thigh on the pelvis or if the thigh is fixed it will flex the pelvis. The vastus internus draws the patella upward and inward.

Surgery

The femoral nerve may be injured in fractures of the pelvis particularly if the ascending ramus of the pubis is broken. Fracture of this bone usually occurs near the point where the nerve crosses the bone. It may be injured also in fractures or dislocations of the femur or it may be compressed by pelvic tumors which grow downward along the inguinal canal. Because of its superficial position and its close relation to the femoral vessels it is exposed to stab wounds of the groin. Of course, a wound of any severity in this region is very apt to cause death from hemorrhage or make an amputation necessary. As it enters the thigh the nerve lies externally and above the artery and vein so that the position of the structures from the lateral to the medial sides is nerve, artery and vein. In

certain instances an extensive laceration of the muscles with subsequent scar formation may compress the nerve severely.

It is almost impossible to suture the nerve in the thigh because it breaks up into so many smaller branches so soon after its appearance in the thigh. Other steps such as direct neurotization of the muscles by implantation of the central ends may prove valuable. However, it may be necessary to overcome the disabling deformity of complete paralysis of these muscles by tendon transplantation.

Chapter XXXV

THE CRANIAL NERVES

Few of the cranial nerves are injured alone. Intracranial injury may occur along with more serious injuries to more important structures and early death makes it impossible to

Fig. 299.

Fig. 300.

Fig. 299. Usual limit of sensory loss in complete division of sensory root of trigeminal nerve.

Fig. 300. Deviation of jaw toward paralyzed side in a lesion of motor root of trigeminal nerve.

note their occurrence in warfare. We have observed a small number of lesions of the branches of the fifth nerve. Rarely have we observed an isolated complete paralysis of the seventh nerve. There have been many more cases of isolated injury to the spinal accessory nerve. The glossopharyngeal and hypoglossal nerves were injured together not infrequently in extracranial injuries. These multiple cranial nerve lesions constitute an interesting chapter of the injuries to the cranial

nerves in the World War and will be described in full in the next chapter. We will, therefore, briefly describe the clinical symptoms of injury to the trigeminal, facial and spinal accessory nerves. Of these the facial nerve offers the only practical surgical problem for restoration of its function.

Trigeminal Nerve

Lesions of the trigeminal nerve, while not uncommon, usually occur in one of its sensory branches. (Fig. 299.) Occasionally the motor branch has been included in the injury. At times, the masseter alone or together with the pterygoid and temporal muscles was found paralyzed. In the cases observed by us no loss of taste in the anterior two-thirds of the tongue could be demonstrated. Often the other wounds about the head were so serious that little or no attention was paid to the possible injury of the branches of the fifth nerve. When observed many months after injury in base hospitals, the number of cases which showed a residue of serious injury to this nerve was hardly occasional. When the masseter was paralyzed no tensing of the muscle occurred upon tightly clenching the jaws; and chewing was difficult on that side. In paralysis of the pterygoid opening the jaws and protruding the lower jaw was accompanied by deviation of the lower jaw to the paralyzed side (Fig. 300). There was no indication for surgical interference in any of our cases.

Facial Nerve

Far more frequent were the injuries to the seventh nerve. Here, too, injury to some of the branches was more frequent than injury to the trunk of the nerve. As a rule, such injuries were only incidental to the general mutilation of the face. Rarely was the nerve found to be injured before its exit from the stylomastoid foramen. It is conceivable that it was so injured in many fatal cases of basilar skull fracture and other intracranial injury. It was often found to be damaged in wounds of the parotid region and of the neck. It is notable,

however, that in the material seen numbers of months after injury very few cases of facial palsy were seen.

Wounds of the cranium, particularly in the temporofrontal

FIG. 301. Paralysis of facial nerve.

region, are often accompanied by paralysis of the motor filaments of the orbicularis palpebrarum, or the frontalis muscles. Most frequently some of the branches of the seventh nerve are injured alone. Paralysis of the trunk of the seventh nerve is characterized by complete absence of movements of expression on the paralyzed side, with inability to wrinkle the forehead upward or to close the eye. Attempts to close the eye are associated with a movement of the eyeball upward. This is Bell's phenomenon. In addition to this, the patient is unable to pucker his lips, to smile or show the teeth on the paralyzed side. The expression of the face is characteristic. The paralyzed side is "washed out" and expressionless, and because of atony the angle of the mouth droops, the nasolabial fold is obliterated and there is an effacement of wrinkles on the forehead. Frequently, because of inability to hold the lips closely together, there is drooling of saliva. All of the signs are exaggerated during attempted movements of the face, or during emotional expression, as in laughing (Figs. 301 and 302). When injured within the bony canal before its exit from the stylomastoid foramen, taste is lost over the anterior two-thirds of the tongue.

Frequently the trunk may be only partially injured, and in addition to the preservation of reaction of the muscles to faradic stimulation more than fourteen days after injury,

A B C

FIG. 302. Paralysis of facial nerve (A) at rest; (B) showing teeth; (C) closing eyes.

certain motor signs indicate the recoverability of the lesion. Not only can the eyelids of the affected side be closed more completely than in the case of total paralysis, but twitches can be observed in the lower lid accompanying the winking of the opposite eyelids consequent to threatening gestures. The nasolabial fold is not completely obliterated. The lips on the affected side are not separated and the lower lip upon attempts to show the teeth, although not moved away from the midline, show vertical wrinkling. Even in the presence of a complete reaction of degeneration, these signs may justify us in predicting spontaneous recovery of the nerve.

As in civil life so in military practice it is notable that following incomplete recovery contracture and overaction of parts of the muscles supplied by this nerve occur. Upon closing the lids or winking contraction of the muscles of the lower parts of the face may be observed. Even insignificant injuries to branches to this nerve below the eye are followed by the persistence of muscular twitching coincident with winking. Conversely, in showing the teeth the eyelids of the affected side are more closely approximated.

Anatomy of the Facial Nerve

The facial nerve has its cells of origin in the reticular formation of the lower part of the pons. The fibers pursue a curved course within the pons. They first pass backward and inward and then turn upward and forward to form an eminence on the floor of the fourth ventricle. Finally they bend downward and outward at a sharp angle around the nucleus of the sixth cranial nerve and leave the brain stem at the cephalad border of the medulla.

The acoustic nerve lies lateral to the facial and between them is the nervus intermedius of Wrisberg. This latter may be regarded as the sensory root of the facial nerve. Its cells of origin lie within the geniculate ganglion.

The facial nerve is firmer, rounder and smaller than the acoustic nerve. It passes forward and outward to enter the internal acoustic meatus with the acoustic nerve. At this point the facial lies over the acoustic in a groove formed by the latter nerve. The nervus intermedius lies between them. They have a common sheath which is formed by continuations of the meninges and of the subdural and subarachnoid spaces all of which reach to the bottom of the meatus. At that point the facial enters the facial canal (aquaeductus fallopii) and follows its course through the petrous portion of the temporal bone to the stylomastoid foramen. At first, directed outward between the cochlea and the vestibule toward the inner wall of the tympanum, the canal bends backward and arches downward behind the tympanum to the stylomastoid foramen. At the point where the nerve changes its direction there is a greyish red swelling, the geniculate ganglion.

After its exit from the stylomastoid foramen the facial runs forward in the substance of the parotid gland, crosses the external carotid artery and divides behind the ramus of the mandible into its two primary branches, *temporofacial* and *cervicofacial.* As these two branches and their ramifications separate from each other they present the appearance of a bird's claw (Fig. 303).

In its course the facial forms many communications. Within the internal acoustic meatus there is a small twig which joins the acoustic nerve. Several communicating branches arise from the geniculate ganglion. The great superficial petrosal nerve joins the sphenopalatine ganglion to form its motor nerve. The small superficial petrosal nerve communicates with the otic ganglion. The external petrosal joins sympathetic fibers which accompany the middle meningeal artery. Within the facial canal a communicating twig joins the nerve from the auricular branch of the vagus. After its exit from the sytlomastoid foramen the facial sends a small branch to the glossopharyngeal and another to the vagus. At the same level communicating branches join the great auricular nerve of the cervical plexus; the small occipital nerve behind the ear; and the terminal branches of the three divisions of the trigeminal nerve. In the neck the facial communicates with the transverse cervical nerve.

Several larger branches of distribution arise from the facial in its course. The tympanic branch arises opposite the pyramid, passes through a small canal in the bone and supplies the stapedius muscle.

The *chorda tympani* is given off about a quarter of an inch above the stylomastoid foramen. This nerve passes from below upward and forward within a distinct canal. It enters the tympanic cavity through an opening on its posterior wall between the opening of the mastoid cells and the attachment of the tympanic membrane. Here it is covered by mucous membrane. The nerve passes through the tympanic cavity and over the handle of the malleus. It leaves the cavity through a foramen at the medial end of the fissura petrotympanica (Glaseri). It then descends between the two pterygoid muscles, meets the lingual nerve at an acute angle and accompanies it to the submaxillary gland. Part of the nerve joins the submaxillary ganglion while the major portion continues through the muscular substance of the tongue to the mucous membrane which covers its anterior two-thirds.

(To Be Concluded)

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